the Petroleum Engineer

FOR MANAGEMENT

Management & Tomorrow's Economy
What You Should Know About Taxes
What Management Can Do To Improve Communication
Third Quarter Financial Reports

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

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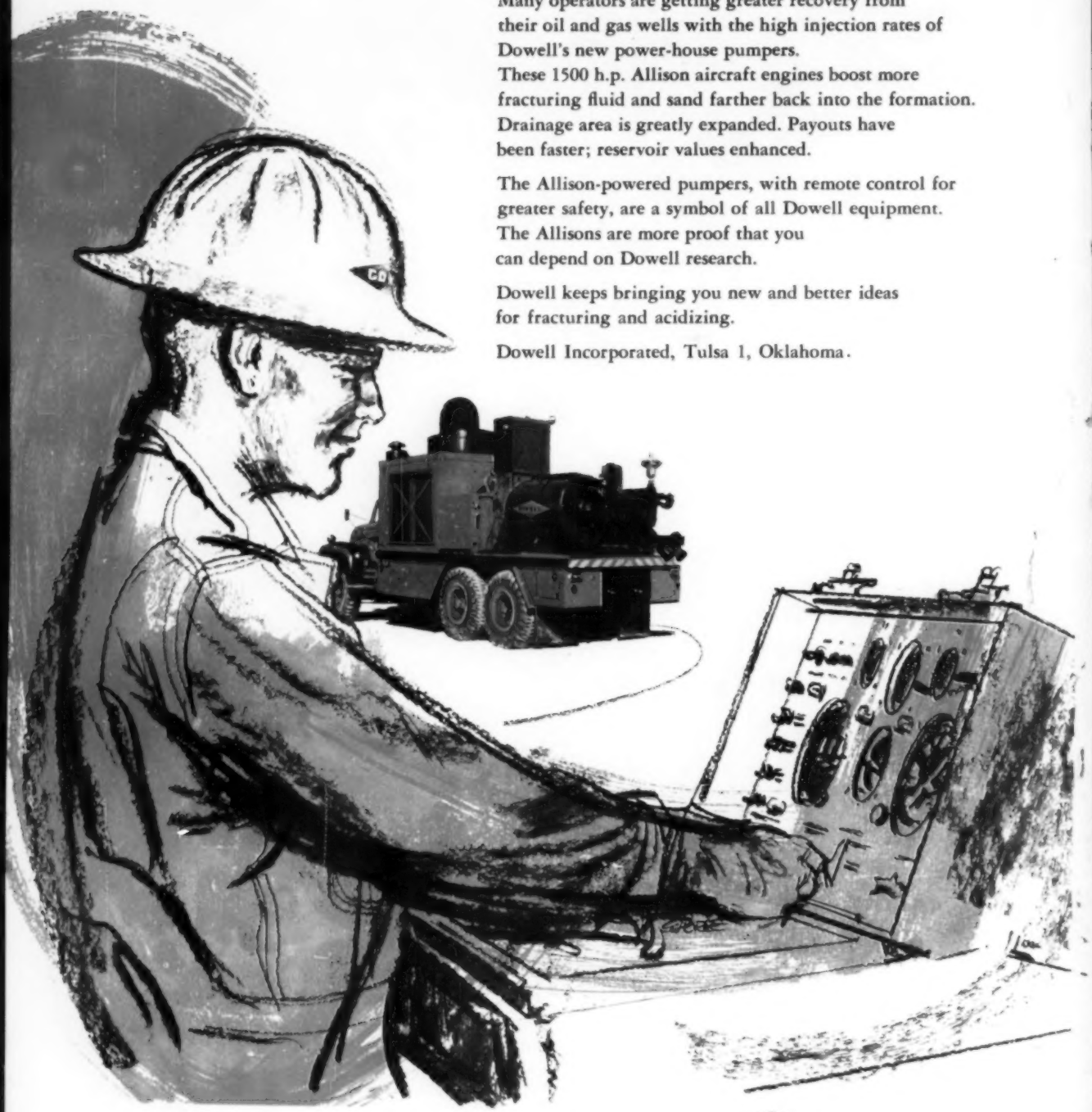

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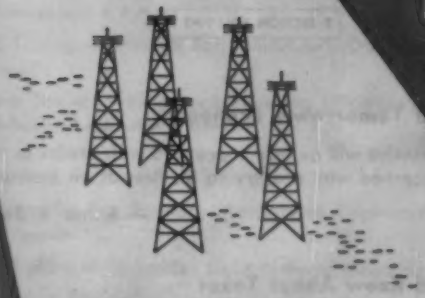

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A Magazine of Petroleum Management

the Petroleum Engineer

FOR MANAGEMENT

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Those Figures Are Out Of *Step*

Our industry is working with some economic tools as awkward to use as oilfield equipment in the days before standards were set up.

Your company and your organizations probably have economists on the staff or hire consulting economists. With their eyes on figures and facts of the present the economists cast with care a shape of the future.

But the figures so often do not have a full description and the shape of the future follows a distorted line.

Suppose your company needs industry-wide capital expenditure data to help in determining its own needs. As you know, this one figure requires explicit limits. For instance, does the total figure cover world operations or the free world only? Does it include only companies in the U. S.? Or expenditures by U. S. companies in the U. S. and abroad? All these questions, you will see, cover only one phase — the area involved.

We see a wide range of estimates of capital expenditures for our industry. You can take your choice of anything from less than $5 billion to more than $8 billion. Most of them are pretty reliable, too, if you know what companies and what areas they include, what departments are involved, whether intangible drilling costs are capitalized, etc.

But these varied figures are often labeled simply "capital expenditures."

Confusion easily slips in with oil reserve estimates. Differences in methods of estimating are as wide as differences of opinion. It is hardly surprising that even recent Middle East reserve estimates range from 74 to 230 billion barrels. Perhaps the minimum estimate is enough to keep crises arising in this troubled area, but there may come a time when peace will hang on an accurate report.

The world bumbles on but what of your company? You must take immediate steps for future security and progress. Information is your economic planning tool. Yet one company this year consulted four valuation companies and obtained four estimates from 75 to 115 million barrels.

As the necessity for short and long-range planning becomes more critical in our fast-moving economy, the need grows for more specific and more uniform data. More study should be given the purposes of economic forecasts in the petroleum industry and the requirements that will meet those objectives.

There are indications that part of our rough going in public relations falls upon the haphazard use of economic data that is not too well defined. "One in nine finds oil" is certainly ambiguous.

How can the petroleum economist improve his tools?

First, he should be able to discuss his problems with others in his field — not simply as an economist but as a *petroleum* economist.

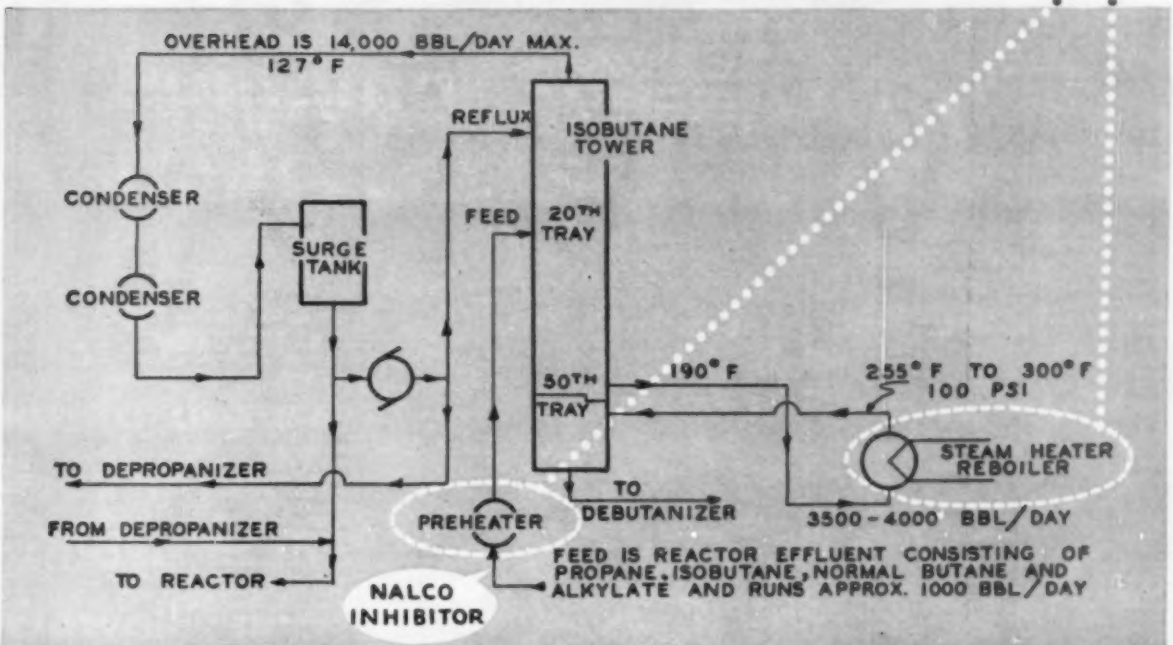
The value of his work has risen so rapidly that until now the petroleum economist has been given little recognition. There is at present no association devoted to economics as such in the oil and gas industry. We believe this type organization would be able to clear up many hazy areas and provide the industry and the companies in it with more precise information.

Good economic tools are essential for industry progress and for improved public relations.

Ernestine Adams

Nalco INHIBITORS GET RESULTS AT THESE TYPICAL TROUBLE-SPOTS

IN AN H_2SO_4 ALKYLATION SYSTEM



THE PROBLEM	THE TREATMENT	THE RESULTS
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Petroleum Profile

RUSSELL S. McFARLAND

President

Seaboard Oil Company

IF you can accept the paradox of "sturdy daring," you have a good basic idea of Russell McFarland's character. And largely because of him, his company has acquired an unusual reputation. Seaboard Oil Company is a highly successful conservative exploration company. The only way oil and gas exploration can be conservative is to find more men like Russell McFarland.

You have to have plenty of courage, too. When Mr. McFarland went to Dallas, Texas, in 1931 as vice president in charge of Mid-Continent operations for Seaboard, he had a one-room office, a secretary, and 10 barrels a day oil production. The first thing he did was sell this production and set up a completely new plan of operations. He took off on a constructive development program which has contributed greatly to Seaboard's oil field discoveries.

When McFarland came with the company in 1931, Seaboard's only other production in the United States was in California. Since then the company has found oil in Wyoming, Texas, Oklahoma, New Mexico, Louisiana, Arkansas, and Alberta, Canada, and its operations are being extended into Venezuela and Turkey.

Mr. McFarland was born in Denver, Colorado, and his entire career has been in the petroleum industry. Upon the death of his father, a Presbyterian minister, his mother moved her family to Parkville, Missouri. Here Russell worked his way through Park College, a Presbyterian school. After receiving his AB he went to the University of Missouri's graduate school to study geology. He had his thesis accepted for his master's degree but instead of taking the necessary oral examination, he took a job. When Dr. E. B. Branson, head of the School of Geology, decided McFarland was not coming back for the oral examination, he sent him an AB degree from the University of Missouri. The Seaboard president has the unique distinction of having two AB degrees!

The year 1917 was early days for petroleum geologists. Henry L. Doherty of Empire Gas & Fuel Company (Cities Service), however, assembled a sizable staff and young Russell McFarland was one of these.

Attaining the respectable title of petroleum geologist, he hurried back to Parkville to marry Jeannie L. McRuer, his classmate through high school and Park College. He spent two years with Empire, taking time out for six months with the Air Corps in World War I.

With his full share of self-reliance, McFarland quit his job after two years' experience and set up as consultant geologist in Dallas with the late Dr. Robert T. Hill. In 1920, however, the price of oil dropped to 50 cents a barrel and consulting geological work ceased, so McFarland went with Twin States Oil Company (Sun Oil). He soon was promoted to superintendent of land and geological departments and later became secretary of the company.

McFarland was vice president of the American Association of Petroleum Geologists in 1925 and president in 1928. His term as president coincided with the active development of the major Seminole field in Oklahoma. Wells were drilled so close together and with such speed that crooked holes resulted which hampered geologists in their subsurface work and created serious engineering and legal problems.

The geologists contended that with the help of petroleum engineering such improper drilling practices could be eliminated. As McFarland already was making talks before the various societies of the AAPG, he decided that the best way to remedy the situation was to expose just how crooked the holes really were. Considerable objection was raised in the industry but the late J. Edgar Pew, vice president of Sun Oil Company, gave him the green light. The frank discussions he led throughout the Southwest before geological societies had a great deal to do with straightening crooked holes and improvement of drilling practices.

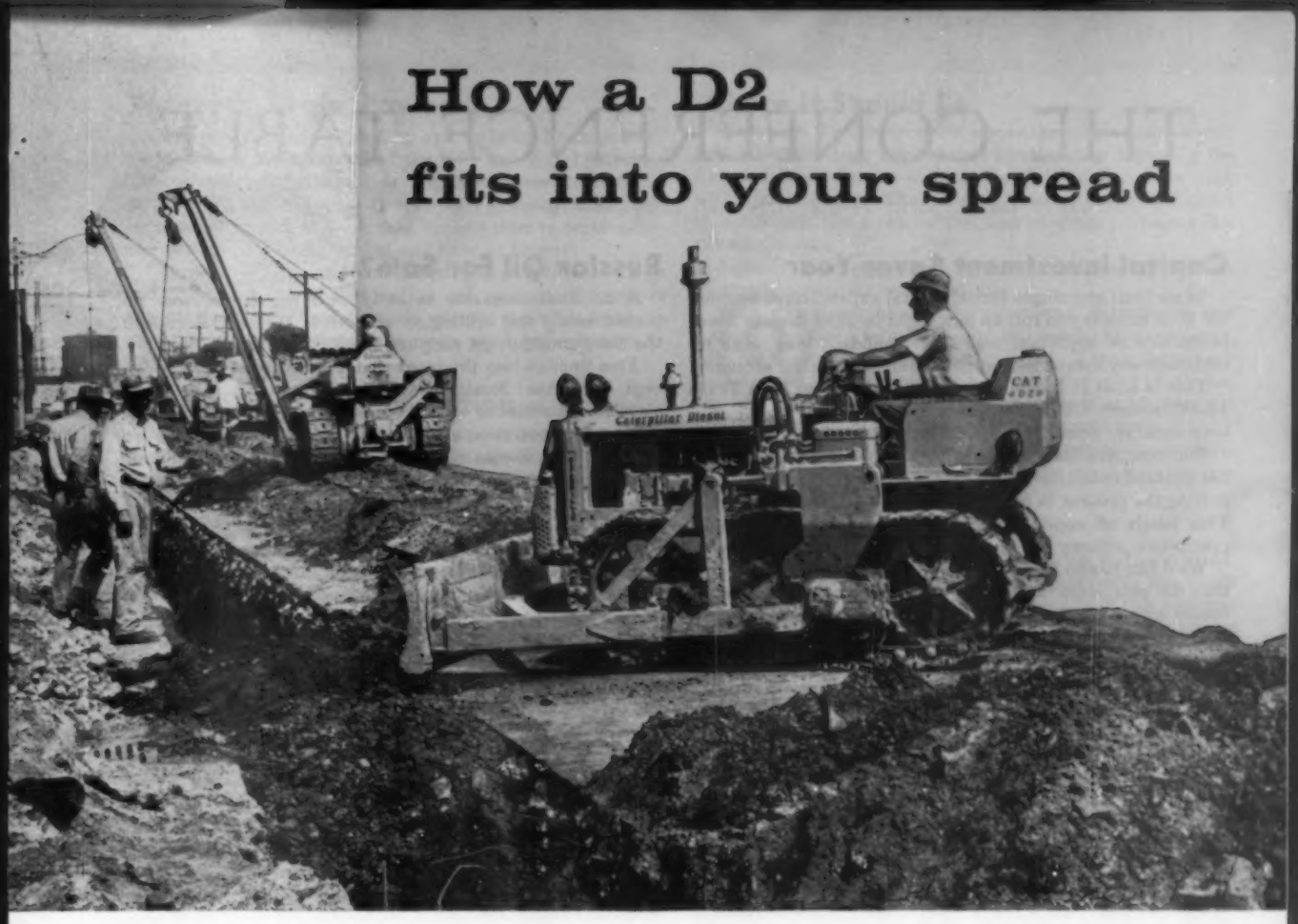
In 1929 McFarland left Twin States to become vice president, director, and general manager of Sunray Oil Company, Tulsa. He went with Seaboard in 1931, advancing to president in 1953.

Like all leaders, McFarland has contributed effective effort to his industry and his community. He is a member of NPC, AIME, a director of API, of IPAA, and of Texas Mid-Continent Oil & Gas Association, which in 1949 presented him with a Distinguished Service Award.

Back in 1934 he, Harry Moss, Bob Whitehead, and Carl Young started what is now the Dallas Petroleum Club. Times were rough and friendly cooperation not easy to achieve but the four men persisted and the organization worked. McFarland was president of the club for two successive years.

The McFarlands have a daughter, Mrs. Jerome Cartwright, and two sons — Russell and Douglas — both of whom have followed their father into the oil industry. Mr. and Mrs. McFarland spend most of their vacations in Colorado, where he can indulge in his hobbies of golfing, photography, fishing, and hunting. These are good recreations for a man with a demanding mission — the job of finding oil.

How a D2 fits into your spread



THE efficient, versatile CAT* D2 Tractor is an ideal unit for pipe-line work in confined quarters or on busy city streets. Not only is it extremely maneuverable, but it is designed to give you high production.

Gragg Canada, Ltd. of Toronto is using a D2 with a No. 2A Bulldozer on a 21-mile natural gas line of Consumer Gas Co. in metropolitan Toronto. It is being used principally for backfilling.

Texas Allen, general manager, says, "This machine stands up well under very rough working conditions."

It is engineered to give you top performance—from track bolts to drawbar pins. The D2 has aluminum alloy main and connecting rod bearings; heavy-duty track rollers; heat-resistant alloy steel valves, high-strength "Zerol" bevel gears; a rugged five-speed transmission. In any climate, you can be sure the D2 will start when you need it because it has the exclusive Caterpillar all-weather starting engine.

And now you can order the D2 equipped with the new Caterpillar field-tested oil clutch. If your job is tough on tractor flywheel clutches, you'll find the new clutch increases dependability and reduces service and maintenance costs. Clutch adjustments are rarely required and disc replacements are needed no more frequently than engine overhauls.

Behind the D2—like all Caterpillar-built equipment—stands an army of expert service personnel. You'll find them, and complete parts and service facilities, wherever the pipe takes you.

So see your Caterpillar Dealer when you're figuring machine and equipment needs for your next job. He has the units to fit your requirements *exactly*. And he'll demonstrate on your job. Call him today.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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NAME THE DATE... YOUR DEALER WILL DEMONSTRATE

THE CONFERENCE TABLE

"First get your facts; and then you can distort them at your leisure." MARK TWAIN

Capital Investment Saves Year

More than any single factor, capital expenditures enabled the U. S. economy to roll up new highs in 1956 despite lower production in important segments. Confident long-range investment was a stabilizing and dynamic force in our economy.

This is what L. L. Colbert, Chrysler president, told Texas Mid-Continent Oil & Gas Association, and he should be a keen observer since the automotive industry had a big slump.

The new emphasis on growth over the long pull, he said, has enabled industrial management to develop a new way of putting the present in perspective with the long-range future. This levels off capital expenditure fluctuations that could precipitate a slump.

We'd like to add that no industry has been more far-sighted than the petroleum industry in preparing for demands of the future with capital investments that climb higher each year.

Petroleum Engineer estimates for investment of U.S. oil companies at home and abroad in 1956 are $7.4 billion. (See Page E-10.)

Twelve Top Treats

Never has a *Petroleum Engineer* series attracted more attention than our series on Communication by Dr. Dennis Murphy. Hundreds of copies of separate chapters have gone out in answer to individual requests. Several of the articles have been reprinted. *Executive Review*, for instance, reprinted "Twelve Tips on How to Dictate a Letter" in October.

Now the big news — all 12 chapters under one cover! You can have a copy with a year's subscription — new or renewal. Communications is an easy, quick-opening door to improving your own efficiency. And it's fascinating reading — truly 12 top treats.

Esso Educational Support Up

The Esso Education Foundation has granted $1,191,450 to 297 privately supported colleges and universities in the U. S. for the 1956-57 academic year.

Last year the Foundation, sponsored by Standard Jersey and a group of affiliates, granted $1,067,900 to 226 schools.

The largest portion will be given in unrestricted grants for undergraduate education. Next largest part was granted to 16 institutions for capital projects. Other grants are for research, medical education, human relations, etc.

The Esso Educational Foundation was used as an example (The Petroleum Engineer, September, 1956, Page E-25) of one method used by oil companies of supporting education. Each large company has its own method of aiding in the great task of promoting higher education. We hope to go into more of these later.

Gas Taxes Top $4 Billion

Motor fuel taxes will reach a record high of more than $4 billion this year, according to APIC statistics. With 50 per cent increase in federal gas tax rate, total receipts under the federal tax will reach an estimated $1.3 billion for 1956. State gas taxes will be $2.7 billion.

State and federal taxes on gasoline reached a billion a year in 1939, passed $2 billion in 1950, $3 billion in 1954.

The increase to 3 cents a gallon for federal tax was imposed July 1 to help finance the national highway program. In some states, combined sales taxes on gasoline go as high as 12 or 13 cents a gallon.

Russian Oil For Sale?

A national magazine recently said the USSR was reported ready and willing to sell oil to Western Europe if the Suez situation cut supplies from the Middle East.

This implies two premises that we would hesitate to accept. First, that Russia has enough production to sell any sizeable quantities of oil and, second, that Russia can quickly change transportation of oil in her limited system. It is even doubtful that Russia could help supply her protege, Egypt, in case of further conflict.

Hoover Cites Engineer Shortage

The most famous engineer, former President Herbert Hoover, told a New York audience recently that the engineering profession is faced with a crisis involving the fate of America. Said he:

"We have a heartbreaking decrease in our young men and women willing to enter our universities and face the rigors of engineering and scientific training.

"Other nations are outstripping us, and unless we find a remedy we shall have a decline in industrial progress and public improvements."

The Enigmatic Industry

A new booklet approaches the oil industry from the standpoint of individual experiences. Gulf sponsored the publication, "The Industry Nobody Really Knows," written by Craig Thompson, who also wrote "Since Spindletop", a brief history of Gulf Oil Corporation.

In "The Industry Nobody Really Knows," Hugh Roy Cullen represents the oil finder; Paul Cormier, a production man; Craig Rumbaugh, an oilfield trucker; Harry Rosen, a drum reconditioner; Arthur O. Putnam, an oil products salesman; M. M. Fowler, a commission distributor; Tom Burns, a service station operator.

This is another effort of an oil company to reach understanding with the public. We have an idea it would attract more readers with some title like "Secrets of the Oil Industry".

Glimpse Into Future

The philosophy of management about 1975 is the intriguing theme of our lead article by Arthur S. Barron, a management researcher. His estimate of the effect of automation is interesting and may be valuable applied to individual companies.

You may not agree with the statement: "The business firm is becoming less of a private enterprise and more of a public institution", but you will admit that Barron provides good arguments for his views.

Another automation story (Page E-19) describes a new system of dictation and inter-office contact that is said to be unique. In this setup you dictate into your telephone and send files through an automatic pneumatic system.

Wanted: Brain Power

"Survival depends on finding and utilizing brain power," said Howard A. Meyerhoff at the API meeting in Chicago. The executive director of Scientific Manpower Commission said the oil industry must face up to the almost insoluable problem of having fewer highly trained men to serve when the demand is greater than at any time in history.

"Larger numbers of technical people simply are not in sight", he said, noting that college age youngsters comprise the smallest group in history. He advised the oil industry to surround the ones they have with good environment to "stretch their mentalities."

Promotion by Computation

In General Electric your job will find you out by computer. Descriptions of some 10,000 engineers and scientists are fed into a central processing system. This includes education, experience, personality, potential.

A description of the job that needs to be filled is put into the system and names of those whose qualifications match the requirements come out. The machine then proceeds to select the best man for the job.

Make State Hall of Fame

Two Oklahoma oil men — Senator Robert S. Kerr and C. B. Goddard — received high honors recently when they were inducted into the State's Hall of Fame.

Senator Kerr, chairman of the board of Kerr-McGee Oil Industries, Inc., was president of Kansas-Oklahoma division, Mid-Continent Oil and Gas Association for six years. A former governor of Oklahoma and present senator, he is also a tireless civic and church worker. His understandings of the petroleum industry led to his sponsoring the Kerr bill freeing natural gas producers from federal control. It was vetoed by President Truman.

C. B. Goddard was one of the organizers of the Humble Oil Company in 1910 and represented that company in Ardmore in 1912. He had an early start in the oil industry. A wildcat was being drilled on his father's farm near Athens, Ohio, and the operator was unable to pay the crew. When some of them quit, Charles was broken in as a toolpusher at the age of 16. Experience was his pay and from then on he followed the oil play. Retired now, Goddard is a distinguished philanthropist, living with his family in Ardmore.

Another oil man, Roy M. Johnson was master of ceremonies at the Hall of Fame banquet. The widely known wildcatter is president of Oklahoma Memorial Association.

Study Asphalt Economics

Knowing how much asphalt is available, where it is, potential output, and many other facts is important to smooth operation of highway construction. As demand increases for asphalt to supply the new Federal road program, economists of the Bureau of Mines visited the Asphalt Institute at College Park, Maryland, headquarters to correlate petroleum asphalt statistics. At right are: Simon Klosky, assistant chief of the Petroleum Economy Branch; Warren Morrison, Foreign Petroleum Statistics section; Dillard D. Woodson, Asphalt Institute staff engineer; A. T. Coumbe, chief, Fuel Distribution Branch; Charles A. Mayer, Institute staff engineer in charge of production statistics; James Kirby, head of Petroleum Monthly Statistics; Frank Jordan, Oil and Gas Division; Donald Colby, head, Forecast Demand, Petroleum Products.

Where It Should Be

When the British recently opened a large scale atomic power station there were a rash of editorials deploring the fact that Great Britain had left the U. S. behind in its work with atomic energy. There hasn't been so much said about it, but Russia has a reactor building program perhaps twice the size of ours.

Actually, right now, the U. S. has no large scale generation of atomic power for industrial use.

Why should we have? The petroleum industry in this country supplies a more versatile and much cheaper energy. Also we have ample supplies of coal and oil shale for energy uses. Until nuclear energy production in the pilot plants has been brought to reasonable cost and greater safety there is no necessity for building here on a commercial scale.

Great Britain's present shortage of petroleum products because of the Suez situation reveals the need for alternate energy supplies in that country.

Oil Missionary

When K. D. Malaviya, natural resources minister of India, visited Texas oil fields last fall he apparently was much impressed by U. S. oil operations. His guide in this country, Henry Carter Rea, Denver petroleum consultant, is a strong believer in private enterprise and endeavored to sell his visitor on this theme.

Rea feels that private capital could speed India's development of oil resources.

Malaviya was sponsored by the State Department and U.S. oil companies. So far India's technical help has come from the USSR. A team of nine Russian geologists and petroleum engineers are exploring India.

Dollar Value of Human Relations

Although probably no two people will ever agree on the dollar value of human relations in industry, there is greater recognition almost daily of its importance. Editors of *Industrial Relations News, New York,* recently published a book called "The Dollars and Sense of Human Relations in Industry" ($3.50).

Louis Ruthenburg, chairman of the board, Servel, Inc., says, "As we struggle toward the millennium of industrial relations, we shall find management awakening to the fundamental nature of human relations, which has stupidly been relegated to a position of secondary importance."

Not only do the authors boldly assess the dollar value of human relations, they also dig into the subject of morale, another difficult theme. In their discussion of morale, there is emphasis on the fact that morale can't be bought; that "incentive systems lead to restriction of output as frequently as they do to increased productivity."

There are some situations which indicate "output is never restricted because workers disdain good pay; it is restricted because good pay is not enough." One of the main points the editors stress is that company morale is indivisible. It is a giant responsibility for all members of the management from top executives to first line supervisors.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Oklahoma oilfield workers at Climax Molybdenum Company's waterflood leases near Nowata have voted to have the Oil, Chemical and Atomic Workers Union continue representing them. Recent balloting was requested by management following wage dispute early in October, in which employees received a 10-cent per hour pay boost. Union representatives said contract talks would be reopened as soon as election results are certified.

★ ★ ★

Louisiana's offshore claims are being reentered in the U. S. Supreme Court, in an answer to a suit filed early this year by the Justice Department charging the state's seaward boundary extends only three miles into the Gulf of Mexico. Louisiana's case is based on the Submerged Lands Act, passed by Congress in 1953, giving states jurisdiction over coastal waters out to their "historical" boundaries. It's historical boundary, as of 1803, date of the Louisiana Purchase, was out to the twenty-seventh parallel, a point three leagues, about 10 miles, from the coast. Texas and Florida boundaries have already been established as three leagues from the coast.

★ ★ ★

The Cities Service Company has filed a petition in the U. S. Circuit Court of Appeals in New York for a review of the order of the Securities and Exchange Commission denying the company's application for exemption as a registered holding company. In September the SEC refused a Cities Service request until the company alters its present relationship with Arkansas Fuel Oil Corporation, a 51.5 per cent controlled subsidiary. At that time the Commission had advised the company to submit a plan for buying remaining interest in Arkansas Fuel or sell its controlling interest.

★ ★ ★

Suez Canal crisis has prompted the Federal Maritime Administration to bring 9 of its 22 tankers out of mothballs, and the Navy has given similar orders for 8 of its 21. The Maritime Administration is selling at competitive bidding six T-2 tankers from its reserve fleet. These vessels have a capacity of 16,760 deadweight tons and can carry 140,000 bbl of oil. Under normal conditions the administration may not sell reserve fleet tankers.

Natural gas liquid production rose 11 per cent above last year, according to August production comparisons made by the Bureau of Mines. August, 1956, production was 32,700,000 gal. Daily production of liquefied gases at refineries was 5,900,000 gal in August, 18 per cent greater than a year ago. Demand for liquefied gases for fuel and chemical uses in the same period was 14 per cent higher than in August, 1955.

★ ★ ★

Oil and gas leasing on public lands is under study by the Senate Interior Committee, as a result of hearing in Albuquerque, New Mexico, concerning option transfers and complaints in some western states. The committee is expected to bring lease option transfers within acreage limitations in the Mineral Leasing Act. One report cites that the House Interior Committee may investigate complaints in western states that discovery wells are being capped and then kept off production until near the lease expiration date, with result being forced and immediate disclosure of public land discoveries.

★ ★ ★

Navy still maintains it has a right to explore for oil, based on debates, and Supreme Court decisions involving the Naval Petroleum Reserve Act of 1920. Latest efforts by the Navy to drill for oil was recently squelched by Comptroller General Campbell. Hearing to decide legality of the Navy's drilling intentions will probably be held next year by the House Armed Services Committee, with Congressman Vinson of Georgia as chairman.

★ ★ ★

"Producers are being shot at so much that we will need all the help we can get," declared API President Jake Hamon before the recent IPAA meeting. Hamon suggested that difficulties blocking the path to industry unity must be cleared before the public can believe the oil industry is one to be proud of. He suggested that producers should start "taking an interest and try to help solve the problems of the service station operators, the refiners, the pipeliners and the integrated companies."

★ ★ ★

Navajo Indians received a record $27,476,216 for oil and gas leases on Utah and New Mexico lands. Bids were accepted on 52 tracts totaling 112,130 acres in the San Juan counties of the two states. Pure, Sun, and Ohio oil companies jointly paid a premium $7,941,120 for a 2560-acre tract, averaging $3102 per acre — about five times previous high per acre bid. Most of the money from the sale will be deposited to the Navajo Tribal Fund in the U. S. Treasury.

★ ★ ★

Rocky Mountain area is short of petroleum engineers and is neglecting future training, a committee of the Rocky Mountain Oil & Gas Association has reported. The group called attention to the fact that only one college in the area, Colorado School of Mines, is qualified to train engineers, despite what was termed the oil industry's great tax support of schools. The association feels, says W. H. Curry, RMOGA president, state schools have the responsibility to serve the industry, because of the large amount of funds contributed—through taxes—for their operation.

★ ★ ★

Motor vehicle registrations will exceed 65,000,000 in 1956, says the Bureau of Public Roads of the Department of Commerce. The estimate, based on reports of state registration agencies, indicates that passenger cars will number 54,300,000, a 4.1 per cent increase over 1955. Trucks and busses are expected to total 10,975,000, a 3.7 per cent gain.

★ ★ ★

Jet fuel production in the next four years will soar 150 per cent above the present level, says W. S. Mount, chairman of the API aviation technical service committee. The increase Mount predicts, will be "necessary to accommodate rising military and commercial aircraft needs."

★ ★ ★

Manufacturers of oil field machinery and tools shipped products valued at $513,000,000 in 1954 — a 78 per cent increase over 1947, the Census Bureau reports in its report on the 1954 census of manufacturers. In the period from 1947 to 1954, the census reports, average employment in the industry increased 15 per cent to a total of 33,700 employees.

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir, 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir, 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet, 3

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

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PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

Middle East oil output has been cut by 30 per cent. Howard W. Page, a director of Jersey Standard, told Chicago Executive Club that more than 1,000,000 bbl of the area's 3,700,000 daily capacity was lost as a result of the Suez Canal closure and the sabotage of the Iraq Petroleum Company's pipe line system by Syria.

After clean-up work begins, Page predicted it would take at least three months to clear the Canal and at least a year to repair the damaged pipe lines.

★ ★ ★

United States and Venezuelan oil fields will increase production allowables in order to supply some of Western Europe's fuel deficit. Already the situation has brought some price rises. Edging up began first in fuel oil and is expected to spread over most products. This will not be in one jump but a gradual stiffening of prices throughout the nation. The estimated 2,000,000 bbl a day of surplus production will stand the United States in good stead during the present crisis. Middle East action has had a vital impact on U. S. oil policy. This one event has affected oil production and distribution plans throughout the world.

★ ★ ★

Ohio Oil Company announced plans for construction of a common carrier products pipe line from Wood River, Illinois, to Chicago. Pipe is on order and detailed plans for the project are now being completed, according to J. C. Donnell II, president.

★ ★ ★

Canadian oil consumption has increased 214 per cent since 1946, says S. A. Swensrud, board chairman of Gulf Oil Corporation. He cited that in 1946 Canada's crude production was 21,000 bbl daily, while consumption of petroleum products was 223,000 bbl daily. Today, oil production is about 475,000 bbl daily with consumption in Canada estimated at 700,000 bbl daily. In the U. S., in the same 10-year period, consumption has increased about 80 per cent.

★ ★ ★

Six major 1957 goals for oilmen have been set forth by Jake L. Hamon, newly re-elected chairman of the American Petroleum Institute. Hamon's goals, presented at the recent IPAA convention in Dallas, Texas, are: (1) Eliminate difficulties that block the path to industry unity; (2) Guard against the continued agitation over the percentage depletion provisions; (3) Be alert to the widening peril of government domination, whether it be federal, state, or local; (4) Encourage the healthy development of the independent producer; (5) Generate an atmosphere favorable to the enactment of a natural gas bill acceptable to the industry and to the public; (6) Become a united industry.

★ ★ ★

Shell Development is taking another step in tying together the oil and agricultural industries in its expansion program for its Modesto agricultural research center. Construction is scheduled for completion in 1957, of more than $1,000,000 in new buildings and services. More than 100 persons will be employed in the laboratory.

★ ★ ★

A new engineering center in mid-Manhattan, New York City, is in the architectural planning stage, reports Engineering Trustees, Inc., the joint corporate agency of the four major national engineering societies. The group includes the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. A fifth prospective "founder society," the American Institute of Chemical Engineers will be included in the Center project.

★ ★ ★

"The Industry Nobody Really Knows," a booklet published by Gulf Oil Corporation, is the latest of a growing number of privately published publications aimed at giving consumers of all petroleum products a more realistic understanding of how the oil industry actually gets its job done. The 32-page booklet tells oil's story in terms of the individual experiences of independent operators who have only a contractual relationship with any major oil company.

★ ★ ★

Among speakers at the Interstate Oil Compact Commission meeting in Miami Beach, Florida, December 6-8, are Oscar L. Chapman, former Secretary of Interior and Judge Victor R. Hansen, chief of the Antitrust Division of the Department of Justice. Governors of all states were invited to attend the IOCC meet at the request of New Mexico Governor John F. Simms, chairman of the Compact Commission.

Any surplus of oil products in the U. S. must not stand in the way of a crude price increase because "the domestic oil industry cannot go on indefinitely selling crude at prices that are below replacement costs," reports A. E. Hermann, president of the Texas Independent Producers and Royalty Owners. Hermann stated that "responsible studies" show that crude oil — at the nationwide average of $2.75 per barrel — is selling at 50 cents to $1.00 per barrel below the cost of replacing oil under today's costs.

★ ★ ★

Approximately 60 per cent of the exhibitors — representing 90 per cent of the outside space — have reserved their space for the May, 1959, International Petroleum Exposition at Tulsa, Oklahoma. Plans are well underway to make the show one of the big events of the year in celebration of the centennial anniversary of Col. Drake's discovery of oil in 1859.

★ ★ ★

Teen-ager's driving survey conducted by Esso Standard Oil Company is correcting several misconceptions on youth's attitudes toward traffic safety. Esso found that 95 out of 100 teen-agers interviewed favored more highway-safety reminders and safety education for younger drivers. Nearly two-thirds considered such effort more important for teen-age drivers than for adults.

★ ★ ★

Internal Revenue Service has issued a proposed recoding of income tax rules including several on oil and gas depletion provisions. The government is now hearing views of interested parties, particularly on a new provision affecting oil and gas depletion allowances and concerning the right to aggregate properties instead of reporting on each property separately. Another proposed revision would allow the taxpayer to deduct exploration expenditures paid or incurred in any amount not to exceed $100,000 for any taxable year. Existing law set this figure at $75,000.

★ ★ ★

Shorter workweek demands are to be stepped up by The Oil, Chemical & Atomic Workers Union. A recent issue of the union's newspaper, "Union News," devoted an entire page urging the demand. One of the OCAW's objectives is the 30-hour workweek with no cut in take-home-pay — the union goal for 1970.

Dowell engineers use specialized equipment to perform high-injection-rate fracturing treatments on oil and gas wells.

RIVERFRAC

it could be the best treatment for your well

To an increasing extent, Riverfrac* is proving to be a most profitable well stimulating treatment. More and more operators report that Riverfrac has given greater production increases and a slower decline than oil-base or acid-base well treatments.

Riverfrac uses unthickened water as a fracturing fluid. Its low cost, low viscosity, and salt-dissolving qualities make water an exceptionally efficient medium for many formations. In some formations, successful treatments have been made without the use of sand as a propping agent.

Dowell additives can be used to extend the successful application of Riverfrac to many zones previously considered incompatible with water.

Dowell was a pioneer in the development of Riverfrac and has an unexcelled fund of experience with this service. An experienced Dowell engineer will tailor a treatment to the requirements of your well. Why not consider Riverfrac for your next job?

If your well is a good prospect for Riverfrac, your Dowell representative can tell you. If it isn't, he will recommend the particular Dowell treatment that should be used.

For service, or more information, contact any one of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write Dowell Incoporated, Tulsa 1, Oklahoma.

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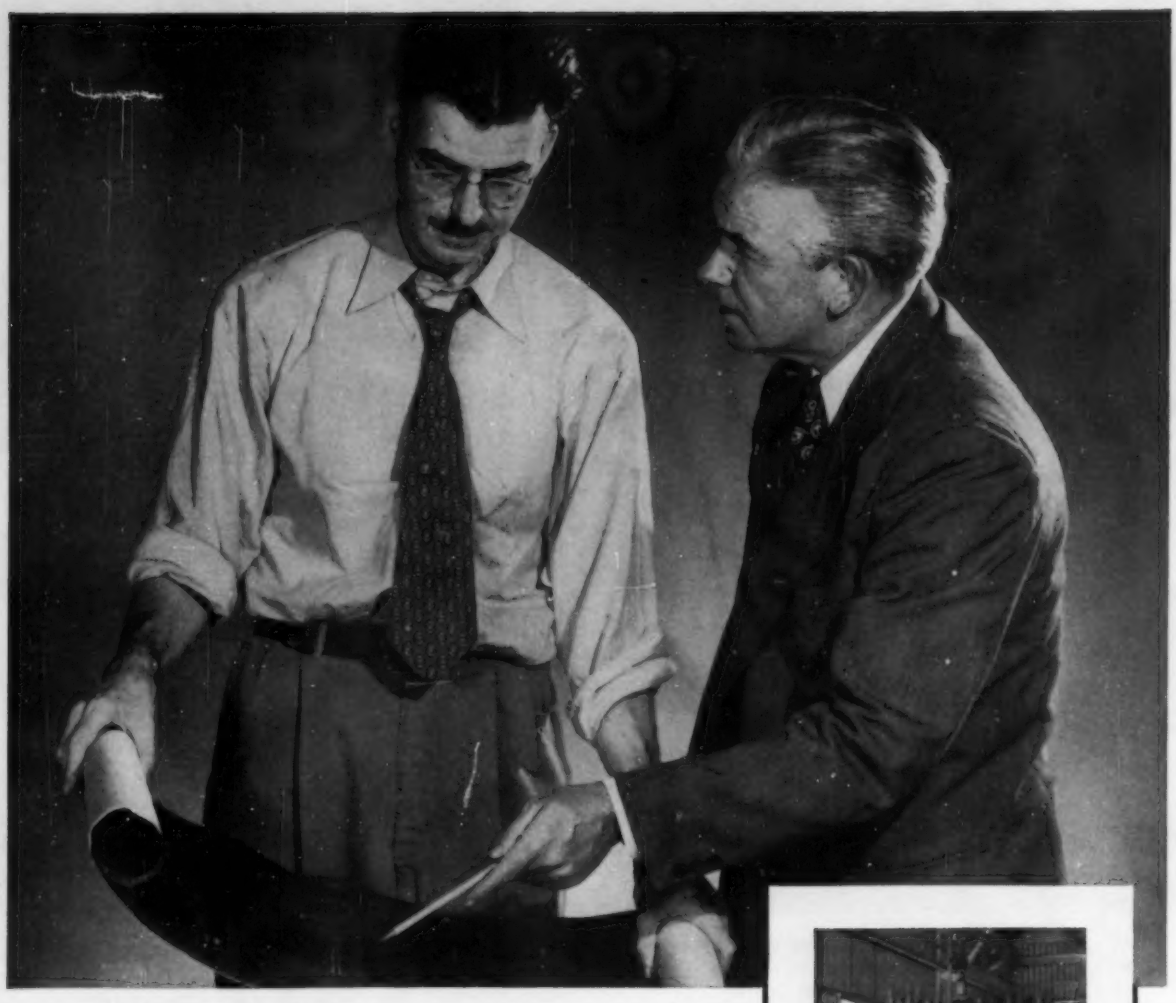


What you need here is an ALDRICH PUMP

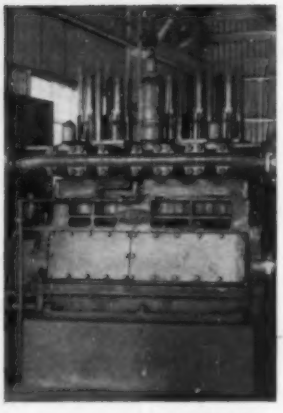
Where pumping operations demand *complete reliability*, Aldrich Pumps assure it—along with unusual freedom from maintenance.

Dependable service. Continuous, heavy duty pumping—at high pressures—is routine with Aldrich Pumps. Aldrich gives dependable low-cost performance in waterflooding, pipe line, gasoline plant, hydrocarbon, injection and petrochemical services. The simplicity of the Aldrich Direct Flow design and the reduced space between valves result in higher volumetric efficiency.

Low-cost maintenance. Fluid end sectionalization, with changeable plunger sizes and interchangeability of parts, means long life and fast, easy maintenance. Parts can be replaced easily and quickly, at low cost. Valves can be removed for inspection or replacement without special tools or equipment. Individual sections of the fluid end can be replaced at a fraction of the cost of conventional type fluid ends.

Get full details. Write for your copy of Data Sheet 100, a condensed catalog and selection table covering our entire line. The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

Field parts stock available in Cermi, Ill., Charleston, W. Va., Houston, Los Angeles, Odessa, and Tulsa.



Two Aldrich 3½" x 5" Direct Flow Pumps on lean oil service. Aldrich Direct Flow units are available in 2½", 3", 5" and 6" stroke sizes with 3, 5, 7 or 9 plungers. Sizes range from 25 to 2400 hp.

THE ALDRICH PUMP COMPANY

Meetings

Dec. 3-4—**New Mexico Oil & Gas Association,** annual meeting, Alvarado Hotel, Albuquerque, New Mexico.

Dec. 3-5—**APCA,** semi-annual meeting, Rice Hotel, Houston, Texas.

Dec. 5-6—**The Asphalt Institute,** annual meeting.

Dec. 6-7—**API Oil Industry Information Committee,** Biltmore Hotel, New York City.

Dec. 6-8—**Interstate Oil Compact Commission,** annual meeting, Fontainebleau Hotel, Miami Beach, Florida.

Dec. 9-12—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, Boston, Massachusetts.

Dec. 16-18—**Kansas Independent Oil & Gas Association,** annual meeting, Broadview Hotel, Wichita, Kansas.

1957

Jan. 14-16—**Pipe Line Contractors Association,** Boca Raton Hotel and Club, Boca Raton, Florida.

Jan. 16-18—**Society of Plastics Engineers, Inc.,** 13th annual technical conference, Sheraton-Jefferson Hotel, St. Louis, Missouri.

Jan. 21-25—**American Institute of Electrical Engineers,** 1957 winter general, Hotel Statler, New York City.

Jan. 28-31—**Plant Maintenance and Engineering Show,** Public Auditorium, Cleveland, Ohio.

Feb 8-9—**API Symposium,** Jung Hotel, New Orleans, Louisiana.

Feb. 13-15—**National Association of Corrosion Engineers,** 8th annual corrosion course for pipeliners, Mayo Hotel, Tulsa, Oklahoma.

Feb. 24-28—**American Institute of Mining, Metallurgical, and Petroleum Engineers,** annual meeting, Hotels Roosevelt and Jung, New Orleans, Louisiana.

Feb. 26-27—**API Division of Marketing,** lubrication committee, Sheraton-Cadillac Hotel, Detroit, Michigan.

March 6-8—**American Petroleum Institute,** southwestern district, Statler Hilton Hotel, Dallas, Texas

March 10-13—**American Institute of Chemical Engineers,** Greenbrier Hotel, White Sulphur Springs, Virginia.

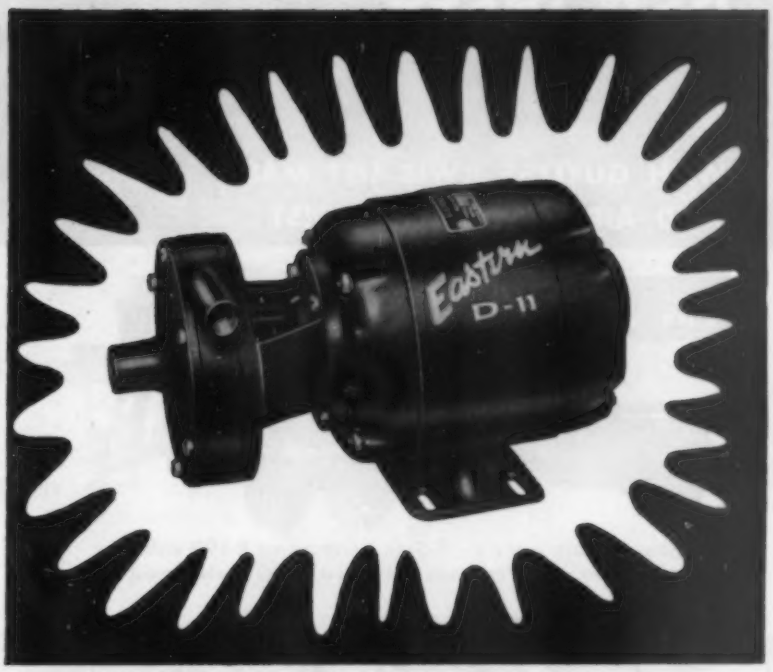
March 10-16—**Engineers Joint Council,** second nuclear engineering and science congress, Convention Hall, Philadelphia, Pennsylvania

March 18-19—**Steel Founders' Society of America,** 55th annual meeting, Drake Hotel, Chicago, Illinois.

March 18-21—**Society of the Plastics Industry, Inc.,** annual national conference and Pacific Coast exposition, Hotel Biltmore, Los Angeles, California

March 20-22—**API Division of Production,** southern district meeting, Washington Youree and Captain Shreve Hotels, Shreveport, Louisiana.

March 21-22—**American Trade Association Executives,** 1957 Washington conference, Mayflower Hotel, Washington, D. C.



24,830 successful installations!

EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-G

Eastern

INDUSTRIES, INC.

100 Skiff St., Hamden 14, Conn.

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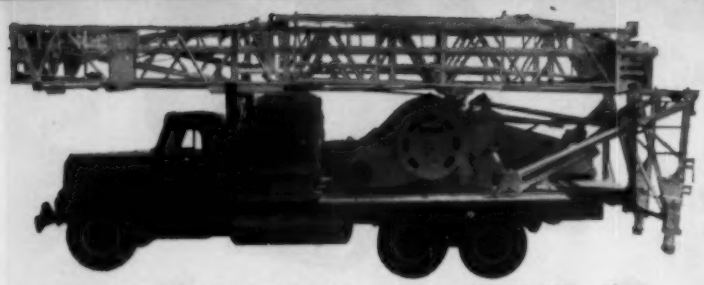
NEW IDECO
Truck Rambler
WITH GUYLESS KWIK-LIFT MAST AND AIR-CONTROLLED HOIST



Shown above is the M-25-S on International R-190 with independent power unit and KM-65-100 D(H) guyless mast

Faster . . TO THE JOB
. . ON THE JOB

This is the world's most modern and efficient well servicing rig—already field-proved from the Gulf to Canada. Let your Ideco man show you why the Ideco Truck Rambler is setting new standards in maintenance of its type.

POWER:

- "Uni-Power" design utilizes truck engine for both propulsion and rig operation through 5-speed mechanical transmission or torque converter.
- Independent power unit on integral skid with hoist also available for truck mounting.

HOISTS:

- Choice of 3 sizes with h.p. input ratings up to 145, 200, and 240. Single or double drum.
- Air controls grouped in single panel at hoist.
- High and low main drum air clutches mounted outside hoist frame for convenient maintenance.
- Precision heavy-duty roller chain on all drives . . . alloy steel sprockets with machined, hardened teeth.
- Heat-treated steel shafts mounted on self-aligning roller bearings; clutch sprockets on ball bearings.

MASTS:

- 65-ft. "D" and "C" or 89-ft. "C" telescoping Kwik-Lift masts . . . Model "D" internally guyed or "C" externally guyed.
- Pole type mast specifications available on request.

When only the best will do . . . Use IDECO

ONE OF THE DRILLING EQUIPMENT LINES

. POST OFFICE BOX 1331 • DALLAS, TEXAS, U.S.A.

March 27-29—**American Power Conference,** Sherman Hotel, Chicago, Illinois.

April 1-4—**AAPG,** national convention, Kiel Auditorium, St. Louis, Missouri.

April 8-9—**Industrial Accident Prevention Association,** annual conference, Royal York Hotel, Toronto, Canada.

April 8-10—**AIME,** open hearth and blast furnace conference, William Penn Hotel, Pittsburgh, Pennsylvania.

April 8-12—**American Welding Society,** Sheraton and Bellevue Stratford Hotels, Philadelphia, Pennsylvania.

April 10-12—**API Division of Production,** Mid-Continent district meeting, Mayo Hotel, Tulsa, Oklahoma.

April 11-13—**AIME,** Pacific Northwest regional conference, Portland, Oregon.

April 16-18—**National Petroleum Association,** 54th semi-annual meeting, Cleveland, Ohio.

April 22-25—**Canadian Institute of Mining & Metallurgy,** annual general meeting, Chateau Laurier, Ottawa, Ontario, Canada

April 24-26—**API Division of Production,** Rocky Mountain district meeting, Buena Vista Hotel, Biloxi, Mississippi.

April 24-26—**Natural Gasoline Association of America,** 36th annual convention, Rice Hotel, Houston, Texas.

April 25-26—**API Board of Directors,** Dallas, Texas.

April 28-30—**Independent Petroleum Association of America,** midyear meeting, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

May 1-3—**API Division of Production,** Eastern district meeting, William Penn Hotel, Pittsburgh, Pennsylvania.

May 6-8—**API,** annual pipe line conference, Cleveland Hotel, Cleveland, Ohio.

May 6-8—**American Geophysical Union,** 38th annual meeting, Washington.

May 13-16—**API Division of Refining,** midyear meeting, Penn-Sheraton Hotel, Philadelphia, Pennsylvania.

May 19-22—**Texas Independent Producers and Royalty Owners Association,** 11th annual membership meeting, Galvez and Buccaneer Hotels, Galveston, Texas.

May 20-22—**API Division of Marketing,** midyear meeting, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

May 20-24—**American Society for Testing Materials,** 5th conference on Mass Spectrometry, Commodore Hotel, New York City.

June 9-14—**API Division of Production,** midyear committee conference, Muehlbach Hotel, Kansas City, Missouri.

June 17-20—**Interstate Oil Compact Commission,** midyear meeting, Canyon Hotel, Yellowstone National Park, Wyoming.

June 24-28—**American Institute of Electrical Engineers,** 1957 summer general, Montreal, Quebec, Canada.

Oct. 9-10—**Third Annual Computer Applications Symposium,** sponsored by Armour Research Foundation of Illinois Institute of Technology, Morrison Hotel, Chicago, Illinois.

Nov. 30-Dec. 1—**Executive Committee of Interstate Oil Compact Commission,** Wichita, Kansas.

Cast Steel Valves for the Petroleum Industry

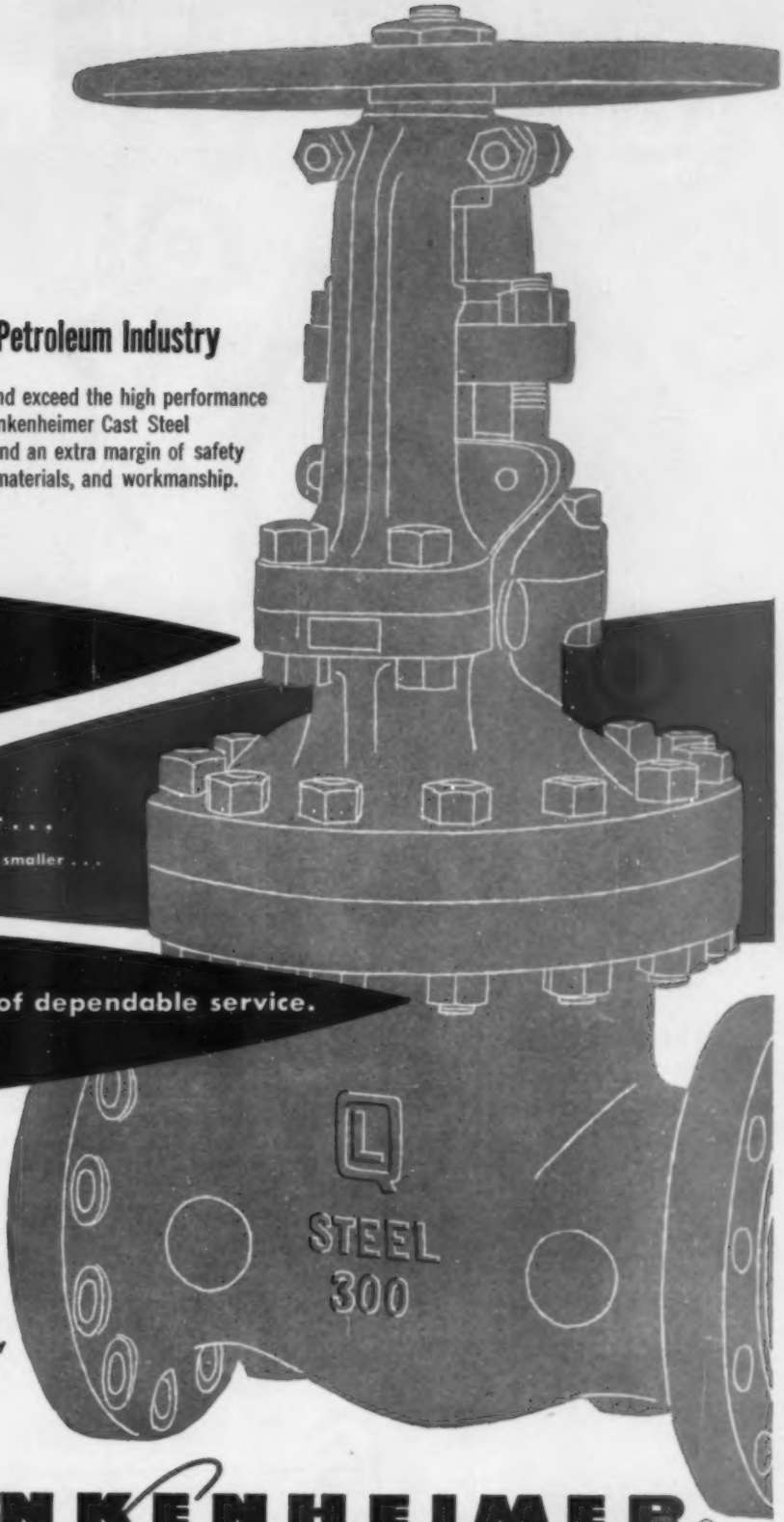
are manufactured to meet and exceed the high performance requirements of critical applications. Lunkenheimer Cast Steel Valves provide longer service life and an extra margin of safety through outstanding design features, materials, and workmanship.

The cost of a Lunkenheimer Valve

gets smaller . . .

and smaller . . . and smaller . . .

with each passing year of dependable service.



A check on the cost of maintaining your cast steel valves will prove this point.

Write for Literature
The Lunkenheimer Company
Box 360, Annex Station
Cincinnati 14, Ohio

LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Naugatuck PARACRIL

The oil-resistant nitrile rubber

"...the rubber we know will resist 'em all!"

"We can't be sure just what kind of oil or other hydraulic fluid will be in contact with our hydraulic hose liners, pressure seals and accumulator bladders, so we use the rubber we know will resist 'em all!" That was the reply when one manufacturer of rubber products was asked about his choice of PARACRIL® for rubber hydraulic specialties.

"In addition, PARACRIL gives us the low-temperature flexibility and other properties needed to meet government specs. The broad range of PARACRIL types enables us to achieve, at low cost, almost any combination of oil resistance and required physicals. We also use PARACRIL for lining our gasoline, fuel oil and liquid petroleum gas hose because of its superior resistance to aromatic hydrocarbons."

Whenever softening or swelling of rubber in contact with oil may decrease efficiency or shorten service life, designers and users alike will do well to specify PARACRIL. Extensive literature on PARACRIL nitrile rubber is now available. Write us the exact nature of your interest in oil- and grease-resistant rubber and we'll gladly send you, without cost, the pertinent technical bulletins.

Naugatuck Chemical

Division of United States Rubber Company
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IN CANADA: NAUGATUCK CHEMICALS DIVISION • Dominion Rubber Company, Limited, Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N.Y.

US RUBBER

". . . they presented unto him gifts; gold, and frankincense, and myrrh."

Window by Charles J. Connick Associates (Boston) in St. John's Episcopal Church, Newtonville, Mass. • Copies for framing on request • (20-1)

Jones & Laughlin SUPPLY DIVISION • TULSA

Now...a New advance in...

Gauge Safety!

Another step ahead in Marsh Gauges: the new Marsh "Safecase". Down to the final detail this gauge is developed for those applications where an unexpected surge of heavy, explosive over-pressure can occur.

In the "Safecase" a solid metal barrier protects the entire face. But, still more important, the *entire back* of the gauge is a thin, ductile plate, designed to open out when subjected to abnormal pressure. Back plate is held firmly to the case by two holding screws and cannot be dislodged by a pressure blowout.

In exhaustive tests it has never been possible to shatter the crystal or create any other dangerous condition in a "Safecase" gauge with its safety-release back. The accompanying illustration shows the result of one of a series of tests in which blank cartridges were fired in the back of the case without even breaking the crystal. Think what that means in safety to operating men!

Yes, an important development . . . but merely the kind you would expect from the manufacturer who originated the "Connoweld" tube, the "Marshalloy" case, the Mastergauge movement and practically all of the major advancements in pressure gauges. Ask for up-to-the-minute information.

Pressure of explosive force merely opens out safety back

Instead of depending on blow-out plugs, entire back of Safecase Gauge is designed to yield to over-pressure. Photo at left shows actual result of firing cartridge within back of case. Safety-release back exhausted pressure. Front remained intact.

MARSH INSTRUMENT CO.
Sales affiliate of Jas! P. Marsh Corp.
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HOUSTON BRANCH PLANT:
1121 Rothwell St., Sect. 15, Houston, Texas
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"THE STANDARD OF ACCURACY"

MARSH GAUGES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

There's a difference in parts quality. And there's a whale of a difference in parts *service*, too.

At your Caterpillar Dealer your order is checked against up-to-the-minute parts catalogs and other *strictly current* references. You're always sure the parts delivered are the *right* parts—they fit and function properly. But while your Caterpillar Dealer naturally excels in emergency service, your needs are mostly routine; and his routine service is quick, accurate and complete, too.

When you need a part, why take a chance? Call on your Caterpillar Dealer. Get CAT* original parts—and SERVICE—every time.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

Your Caterpillar Dealer's parts staff is carefully selected, carefully trained under direct factory supervision. Training is continuous and thorough. The service you get is *expert* service—*Caterpillar service.*

CATERPILLAR*

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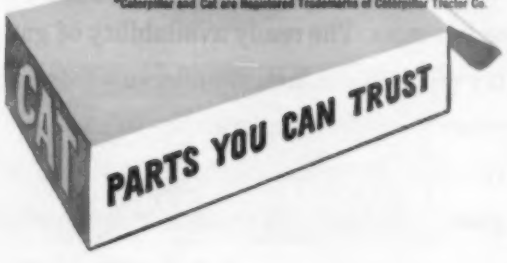

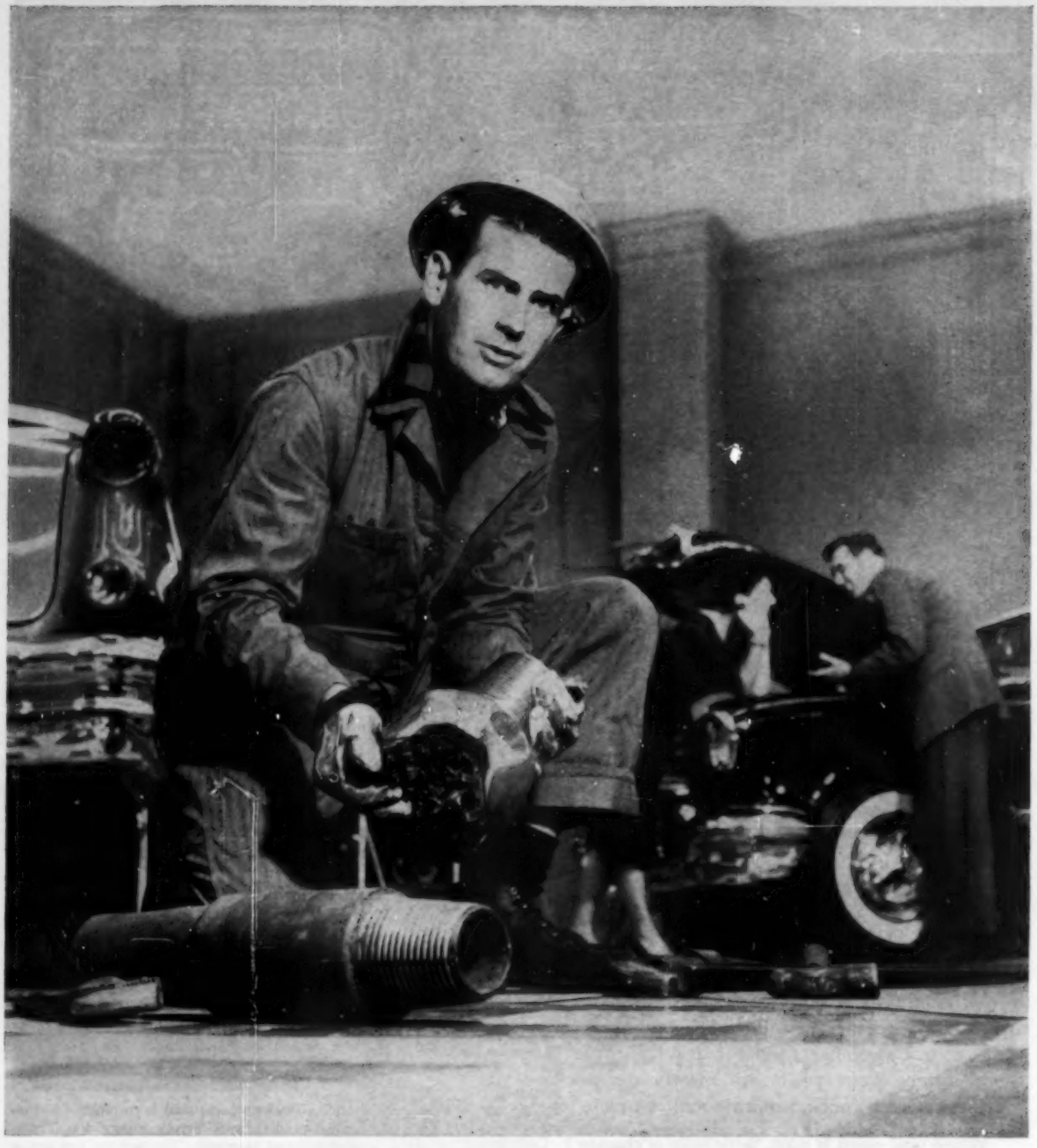

All oilmen make this big sale possible! Americans bought 7,169,908 new cars last year, filled 'em up with gasoline and oil and set out for fun or business. The ready availability of gas and oil helps close every car sale, keeps the auto industry moving. In fact, we oilmen—from drillers to pipeline men—help keep millions working at everything from agriculture to zoology. When you hear someone who doesn't know the facts criticize our industry, speak up. Tell how oil helps keep our strong economy rolling in high gear. Be proud you're an oilman. And tell the world! **SHELL OIL COMPANY**

MEMO Tues. P.M.

Joe—
got a Rush Job—
order me full set of
those little Ridgid
drop-head dies & like—
Hank

Every RIDGID Pipe Tool TESTED individually before shipment

RIDGID OOR
⅛" to 1"

RIDGID 111R
⅛" to 1¼"

RIDGID 12R — ⅛" to 2"

RIDGID
⅛" to 2" Drop-Head Threaders

Handiest darned ratchet threaders you ever used!

Really handy, time savers, easy to use. Pick up the size head you need, snap it into the ratchet ring . . . and start threading! Heads can't fall out. Dies reverse easily for close-to-wall threading. Conduit and special dies available. Free carrier with sets. For perfect threads easily and long service, buy 'em at your Supply House.

Carrier Free with Sets

Bolt Threaders, too—ask for RIDGID OOR-B, same easy-work advantages as drop-head pipe dies.

Whole Line of RIDGID Pipe Threaders Offers You Extra-Easy Threading

RIDGID
Jam-proof 65R
Threads 1" to 2" pipe with 1 set of dies.

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for power drive use—threads 1" to 2" with 1 set of dies.

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2½" to 4" pipe—extra-easy handling, no upkeep.

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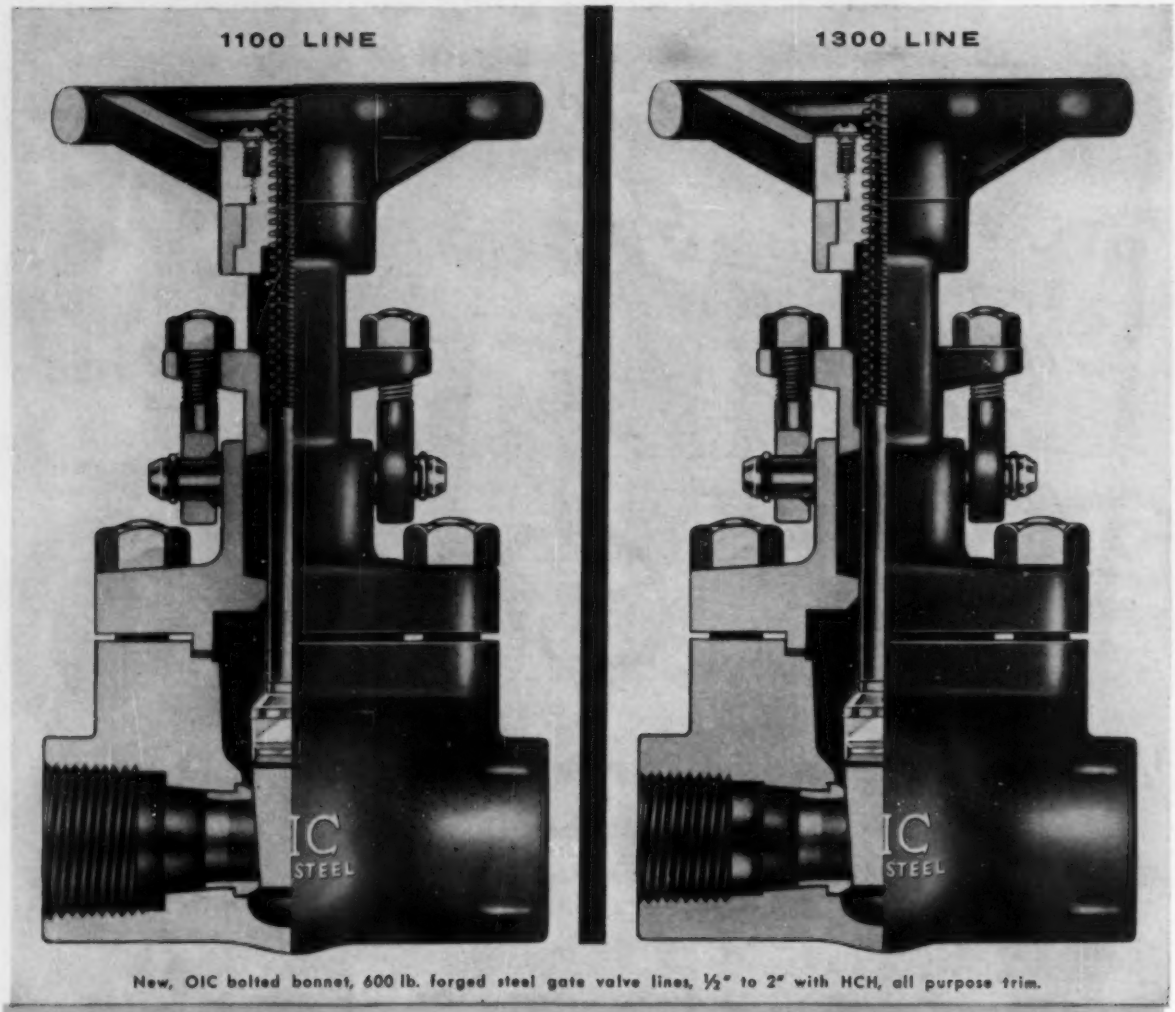
Work-Saver Pipe Tools

The Ridge Tool Company • Elyria, Ohio, U. S. A.



New, OIC bolted bonnet, 600 lb. forged steel gate valve lines, ½" to 2" with HCH, all purpose trim.

2 new rugged OIC forged steel lines

Both feature the modern and rugged bolted bonnet joint, which simplifies and lowers the cost of maintenance.

Both feature a soft iron gasket securely retained in the bolted male and female body-bonnet connection to assure enduring tightness.

Both feature 13% chrome stainless steel trim with 1000 Brinell, duracased wedges.

Both feature plenty of gripping area for pipe wrenches on pipe ends; there's no interference with body-bonnet flanges. Simplifies joint make-up!

The 1300 line includes a *high flow* port area, offering full-flow characteristics.

The 1100 line, with standard flow ports, is compact, economical, and includes the same high quality, rugged features and trim as the 1300 line.

Most valve users have applications suited to both of these new OIC valve lines. Write for Bulletin *#195-R* illustrating features and specifications that fit these newest forged steel valves to your services.

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

VALVES | **FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES**

WHAT DO YOU LOOK FOR IN PIPELINE VALVES?

Positive Shut-Off?

Rockwell-Nordstrom valves are lubricant sealed for *positive, continuous* shut-off on heavy crudes or light gases.

Fast Operation?

Rockwell-Nordstrom valves close with just a quarter-turn. Pressurized lubricant makes operation smooth, easy . . . jacks the plug for *instant* operation.

Clean Design?

Rockwell-Nordstrom valves have *no bonnet or body cavities* to collect valve jamming sediment. Flow is clean as a whistle . . . minimum pressure drop.

Low Maintenance?

Rockwell-Nordstrom valves have *no exposed seats* to wear out . . . lubricant reduces wear for longer life at lower cost.

Versatility?

Rockwell-Nordstrom valves are available in sizes to 30", API ratings to 10,000 lb. They can be ordered with wrench, gear or power operators to fit any need.

Low Cost?

Rockwell-Nordstrom valves cost no more to buy than ordinary valves. And they *stay* reliably on stream at *lower* cost than *any* other valve.

You get all the performance and economy you look for in pipeline valves when you specify "Rockwell-Nordstrom." Get the complete story from your nearby supplier, or write Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed For Positive Shut-Off

40th YEAR *of lubricated plug valve leadership*

Monel Bubble Cups and Tray for top of new fractionating tower completely engineered and fabricated by Fritz W. Glitsch and Sons, Inc., Dallas, Texas. Notice Monel weirs and baffles.

Here's where Monel proves year-after-year resistance to common tower-top corrosives

Tower-top corrosion *can* be held within practical limits.

Monel* nickel-copper alloy bubble caps proved *that* long ago. Their record . . . at temperatures up to 500°F. . . shows outstanding resistance to the aqueous hydrochloric and sulphuric acids and the corrosive salts commonly present in this critical upper section.

Today, for towers handling corrosive streams, Monel alloy is preferred in this location.

The men with the sharp pencils say Monel alloy costs less per pound than other commercially available alloys able to withstand the corrosion in tower tops.

Fabricators such as Fritz W. Glitsch & Sons, Inc., find it is easy to form . . . lends itself well to lined or clad construction. Increasingly, they find it specified not only for caps and trays but also for distribution pipes, fittings, linings, the shell itself and overhead condensers.

Another advantage. Monel equipment can be field erected and easily field repaired. No heat treatment after welding is required to maintain corrosion resistance.

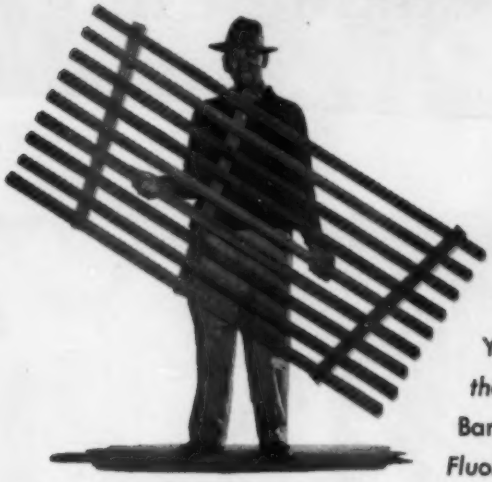
How is your tower down-time record? If it's not what it should be and corrosion is the cause, look into the possibilities of Monel alloy construction. Simply write Inco's Corrosion Engineering Section. *Registered Trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **Nickel Alloys Perform Better Longer**

RE-EXAMINE YOUR COOLING TOWER'S FILLING

It Determines The Life of Your Tower!



A cooling tower's filling is in reality its heart. The design, construction and *ruggedness* of that filling largely determines the life of the tower.

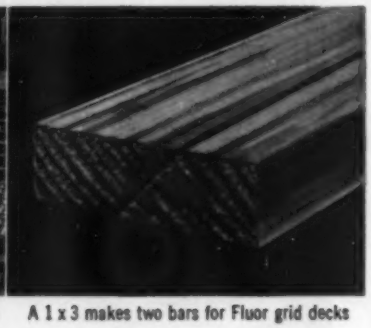
All of the members used in standard Fluor filling have a minimum thickness of one inch. *The life of this fill is several times that of the usual lath type construction!*

You get more years of dependable performance *at the lowest possible maintenance* with Fluor Sloping Bar Grid Decks — *a standard design feature on all Fluor Industrial Cooling Towers!*

Fluor uses only 100% clear all heart redwood for filling

Fluor grid decks are not only sturdily built but are made from the highest grade redwood lumber—100% clear all heart redwood—the finest cut of the log. Clear all heart redwood is free from defects and sapwood and under normal controlled water conditions will give many many years of trouble-free service. We invite you to investigate our filling before making your selection of a cooling tower.

Grid decks serve as scaffolding during erection



A 1 x 3 makes two bars for Fluor grid decks

Grid decks easily support three 200 lb. men

FLUOR PRODUCTS COMPANY

A Division of The Fluor Corporation, Ltd.

General Offices — WHITTIER, CALIFORNIA

Wood Products Mill — SANTA ROSA, CALIFORNIA

Metal Fabrication Shops — PAOLA, KANSAS

MANUFACTURERS AND FABRICATORS OF COOLING TOWERS, PULSATION DAMPENERS, MUFFLERS, PREFABRICATED PIPING AND OTHER WOOD AND METAL PRODUCTS

SALES OFFICES *and* REPRESENTATIVES IN: Birmingham, Boston, Buffalo, Chicago, Denver, Detroit, Houston, Kansas City, Los Angeles, Minneapolis, New York, Philadelphia, Pittsburgh, San Francisco, Tulsa

ASSOCIATES: Fluor Corporation of Canada, Ltd., Toronto; Head-Wrightson Processes, Ltd., London, England

CB&I built Coke Drums . . .

HEART of Twin Coking Units

Four CB&I built coke drums are the heart of two identical coking plants at Union Oil Company's Santa Maria, Calif. refinery. The coke drums are each 18-ft. in diam. by 78-ft. in height and built of ASTM-A-204 plate lined with 1/16-in. Type 405 stainless steel.

The completed vessels were field X-rayed and stress relieved. Stress relieving was accomplished by creating furnaces of the structures and firing large portable oil burners into the vessels to bring them to desired heats.

CB&I's vast experience and complete facilities enable them to engineer, fabricate and erect steel plate structures to the petroleum industry's most exacting specifications. When planning structures of standard or unique design, plan with CB&I. Write our nearest office for complete information.

Twin coking units at Union Oil Company's Santa Maria, Calif. refinery. Both units are equipped with CB&I built coke drums furnished through the Bechtel Corporation.

CB&I

Chicago Bridge & Iron Company

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Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

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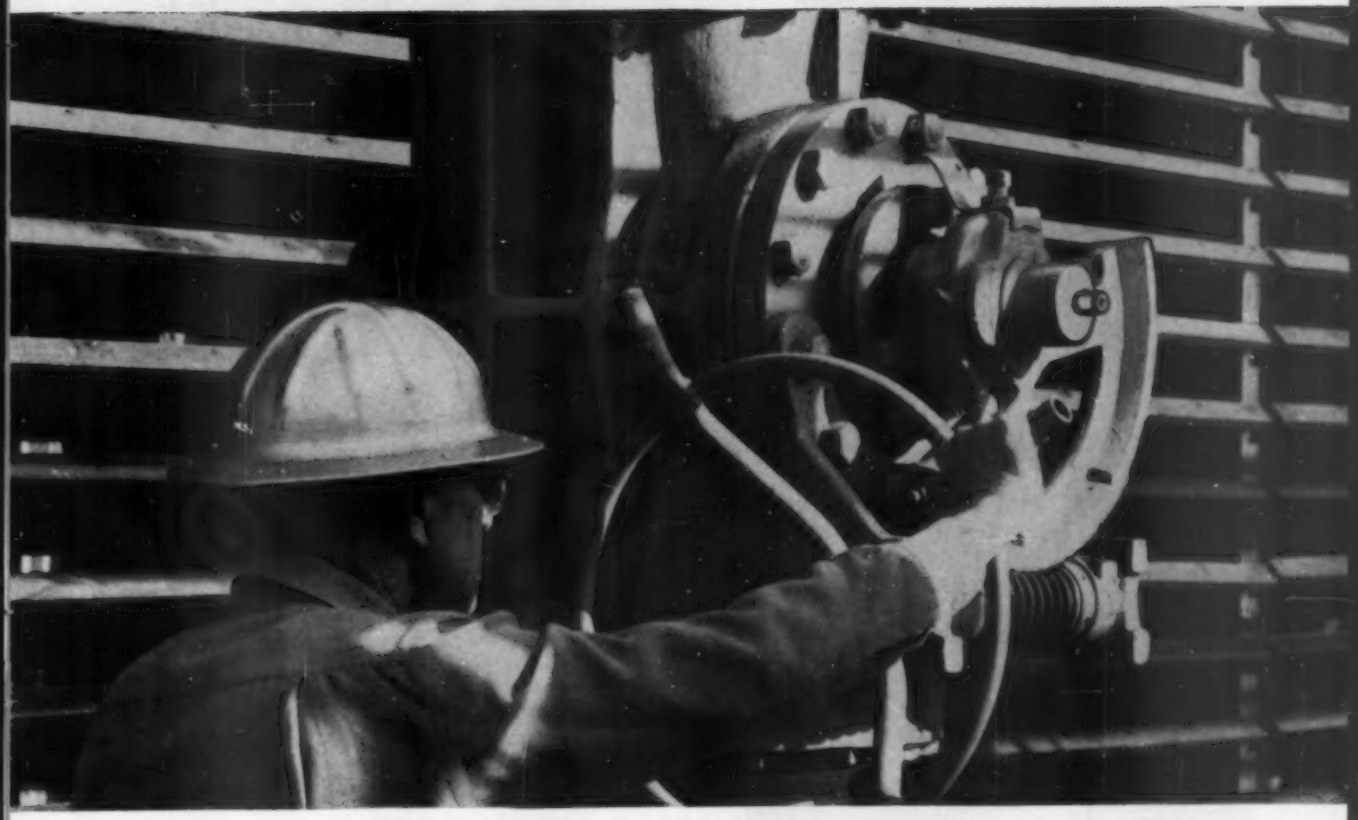


Reduce Down-Time Costs

with ROCKWELL-Nordstrom VALVES

The two most common valve problems that cause excessive down-time costs are seat failure (leakage) and wear. Performance records in thousands of refineries prove that Rockwell-Nordstrom valves cut down-time costs because they *stay leakproof* and *wear longer in service* than any other valve. In Rockwell-Nordstrom valves, seat areas are never exposed to corrosion and positive shut-off is assured by pressurized lubricant sealing. Lubricant also eliminates costly metal-to-metal friction.

Rockwell-Nordstrom cost no more to buy, often less, than ordinary valves and are available in a complete range of sizes and pressure ratings. Write today for more information: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee: Peacock Brothers Limited.*

ROCKWELL-Nordstrom **VALVES**

Lubricant Sealed for Positive Shut-Off
40th YEAR *of lubricated plug valve leadership*

CROSS-COUNTRY at 25 feet per minute

Mobile, utility-size Trenchmobile on rubber tires travels 12.6 m.p.h. — does trouble-shooting, pipe reclamation. It digs main lines, gathering lines, or laterals, 8 to 16 inches wide — 5 feet deep. (Parsons heavy-duty line also includes 3 sizes of ladder-type Trenchliners, full crawler mounted.)

. . . . . PARSONS CO., Newton, Iowa . . . . . .

Send us bulletins on: ☐ 88 Trenchmobile® ☐ 150 Trenchliner®

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY, STATE_____ P&O PE

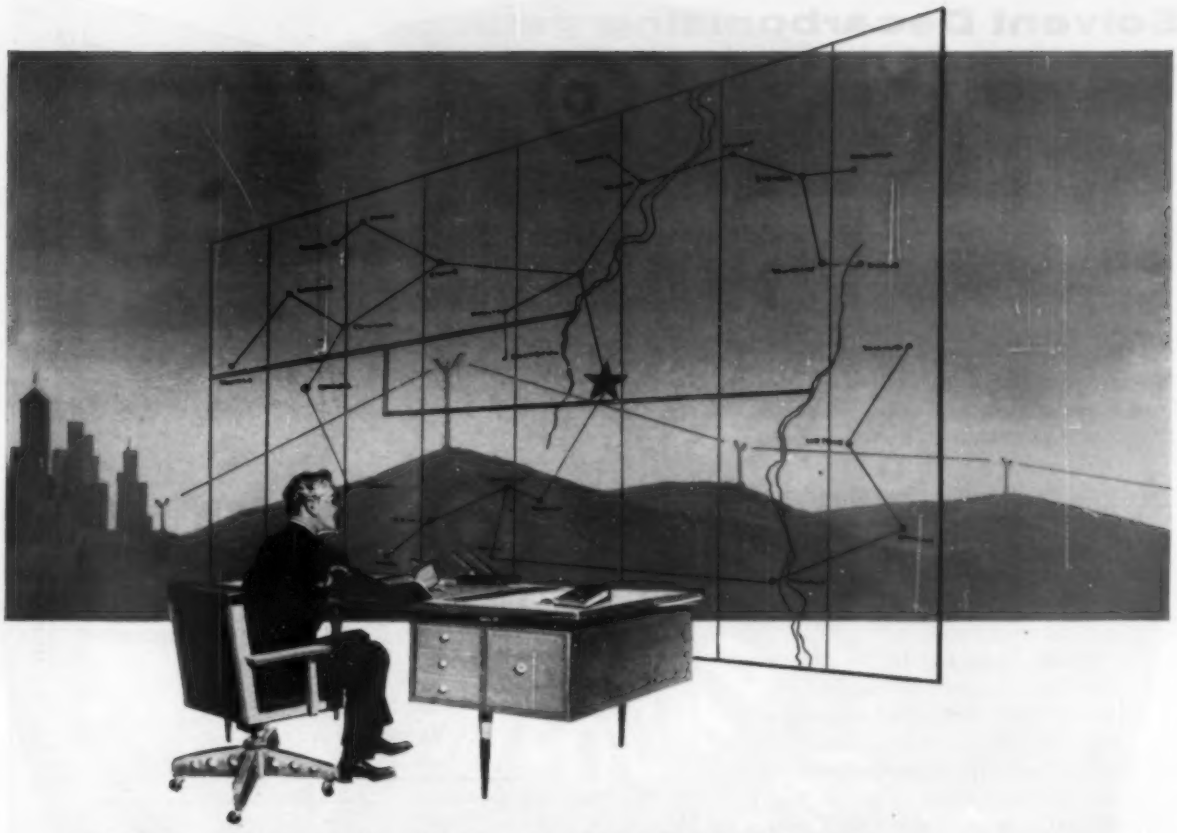
On main-line trenching, or as an auxiliary unit for opening laterals, Parsons 150 wheel-type Trenchliner sets a fast pipeline pace. 30 digging speeds, from 12 inches to 25 feet per minute, give top trench production at every depth, width, and in all soil conditions. Widths range from 16 to 26 inches — depths to 5¾ feet.

Speed and wide work range are combined with precision grading accuracy. A hydraulic ram on vertical mast raises and lowers the digging wheel — gives infinite depth selections, maintains close grade tolerance. A separate ram tilts the mast, balances wheel forward when traveling or trailer-loading. Notice, too, how simple mast design eliminates unnecessary superstructure — gives low overhead clearance, improves accessibility, operator visibility.

Dual-purpose friction clutch drives the digging wheel, and automatically protects against shock loads. Cast-steel buckets with "Tap-In" teeth are interchangeable with gumbo buckets. Shiftable, reversible conveyor discharges to either side. Standard, 16-inch, grouser-type crawlers provide plenty of sure-footed traction for cross-country work. Ask Parsons distributor about it, or send for catalog.

PARSONS COMPANY

NEWTON, IOWA • *(Koehring Subsidiary)*



TEN MILES OR A THOUSAND . . .

Motorola Microwave puts complete operational control at your fingertips

Cross-country or cross-town—Motorola Microwave can give you centralized control in one *complete*, privately-owned communication system that spans city streets, rivers, and mountains with ease. Multiply your present communication facilities with this work-horse that provides multi-channel facilities for transmitting and receiving orders and instructions by voice, printed messages and control signals. It will speed a thousand tasks a day, working 'round the clock to give you better control, improved coordination and increased efficiency . . . all at a substantial savings in cost.

With Motorola Microwave serving all types of applications (many of them in your industry) you get the benefit of extensive experience. In installation after installation, operational records prove that Motorola Microwave performs better, lasts longer and costs less to maintain.

Learn how Motorola Microwave can give you the *complete* communication system for centralized control. Write, wire, or phone today.

VOICE

Private line and party line—manual and dial telephone circuits—VHF mobile and base station 2-way radio . . . *all* can be carried hundreds of miles, economically and privately, by Motorola Microwave.

PRINTED MESSAGES

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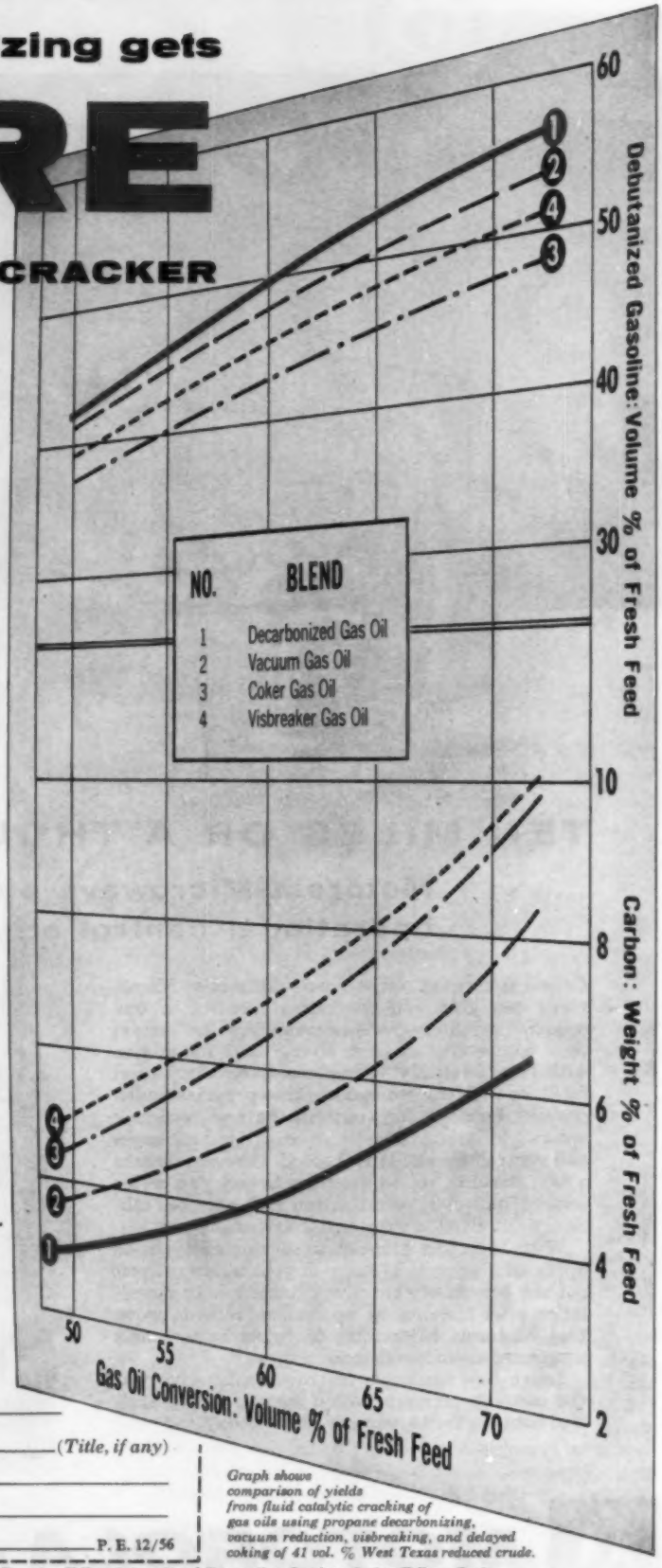

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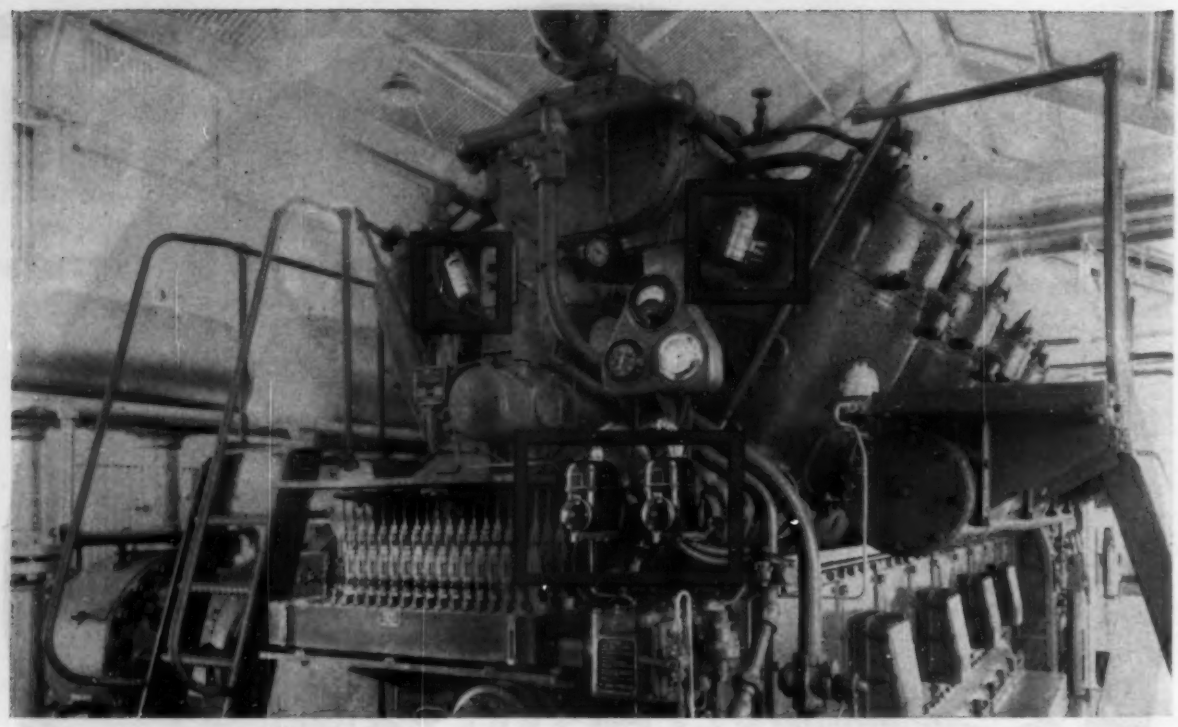

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The *Petroleum* ENGINEER
December, 1956

The future executive will be less concerned with profits as such and more concerned with preserving his firm as an institution

Management and

Tomorrow's Economy

Arthur S. Barron*

IF the statisticians are right, the average big-business executive of 1975 will be 53 years old when he becomes head of the company; a native American; the son of a small businessman or administrator; a staunch Republican; a college graduate with professional training in law, engineering or business administration; and he will have served with his company for approximately 16 years.

The bases for these predictions are the career-lines of top executives from the turn of the century to the present. These have been exhaustively studied by business historians and provide a relatively valid profile of the future executive. Unfortunately, no such data exists for the prediction of what kind of job this future executive will fill. Though we know quite well who the new executive is likely to be, we know little about what he is likely to be doing.

The best we can do in sizing up the executive job 20 years from now is to isolate the basic trends in our present-day economy and then speculate on their implications for business management in the future. Two such trends of crucial relevance to the future development of the executive job are the automation of industry and the increased institutionalization of the business enterprise.

That automation (roughly "the use of machines to run machines") will be in widespread operation in the economy by 1975 is no longer open to question. Recent Congressional hearings, labor's demand for the guaranteed annual wage, the number of new automation journals and magazines, the fantastic increase in the production and sales of self-regulating equipment and computers all testify to this fact. Increasingly, therefore, the executive will be required to undergo (and support) graduate training in the techniques and philosophy of management, to acquire a number of highly specialized skills, to understand fully and to use precise, systematic and scientific tools (of which the much-heralded Operations Research is but one example). Already the proportion of top executives with college educations has increased from 19 per cent in 1900 to 45 per cent in 1950; the proportion with graduate training has increased from 8 per cent to 21 per cent in the same period. Automation should greatly strengthen this trend.

The new professional skills will be needed mostly in the area of decision-making and planning. It is here that for several reasons executive "intuition" and "savvy" will have to give way to more scientific techniques.

First, automation greatly increases what has been termed the "futurity" of management decisions. Not so long ago, most important business decisions were made for two or three years ahead. Under automation, few major management decisions will be made for lesser periods than ten to fifteen years ahead. The long-range capitalization demands of automation, its greater inflexibility in production scheduling, its requirement of continuous operation, and its need for even more far-sighted market forecasts virtually insure this change in the time-orientation of decision-making. Such a development demands truly professional knowledge and skills.

Second, automation vastly increases the need for coordinated planning in the enterprise. The new technology requires an absolute integration of the various functional areas of the enterprise —sales, production, finance and so forth. Management will desperately need the capacity to view the business "as a whole" and to be able to spell out precisely the consequences of a decision in one area of the operation for each of the other areas. This will be possible, however, only through the use of scientific data-collecting processing and communication techniques.

Third, automation demands greater stability of operation. It requires "steady flow" in the productive and marketing process. Nowhere is this requirement of stability more evident today than in the area of labor costs. In the past, fluctuations in production were accommodated with revisions in the work force. Labor was "hired" when production rose and "laid off" when production dropped. Labor costs were, in short, variable. Today, the picture is changed. Under GAW, for example, some labor costs have become fixed. Clearly, then, the financial soundness of an enterprise may depend, in large part, on management's ability to insure stability of operation. The social and technological innovations which are necessary to meet this demand for stability depend on the professional competence of management. In every aspect of decision-making, for that matter, automation places heavy responsibility on the executive.

Of equal significance with automation for the evolution of the executive

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Automation increases "futurity" of decisions; intensifies need for coordinated planning; demands greater stability of operation . . .

job is the increasing institutionalization of business in our economy. What is meant by this sociological tongue-twister is, first, the growing public nature of the business corporation and, second, the growing size, impersonality and complexity of the corporation. The former aspect refers to the external relation of the business organization; the latter aspect relates to its internal organization.

Without question, the business firm is becoming less of a private enterprise and more of a public institution. Its ownership, certainly, has increasingly become more public than private. The growing number of stockholders throughout the nation and the continuing separation of ownership from management are evidences of this trend. There is, besides, the increased interference of government in the running of business enterprises. Business decisions on a number of significant issues are more frequently being made under conditions established by that most public of all institutions —the state. Then, there is the increased role of labor in business decision-making. Even such a matter as plant relocation has become an issue in which labor demands equal participation with management. The opinion pollsters, for their part, point to an increased public interest in business conduct. Each of these factors contributes greatly to the public nature of the business firm. We may expect to see this trend strengthened in the future.

The consequences of this development for the executive job are extremely significant. At the least, management will devote a far greater share of its time to noneconomic functions. Chief among these will be public relations activities — speeches, community projects, publicity campaigns and so forth. It is no mere accident that the public-relations budget of the 100 leading U. S. companies in 1954 amounted to 50 million dollars and that the annual total payroll of all the men and women in public relations is approximately 400 million dollars. These statistics are an indication of management's increased concern with plant-community relations as distinct from internal plant relations.

We may also expect greater management participation in government on the policy-making and high administration levels. In the next twenty years, it is likely that companies will regularly provide "sabbaticals" so that top personnel will be able to put in their stint at Washington.

The need to develop a new philosophy of management which will spell out the social and moral responsibilities of business to society is yet another consequence of the growing public nature of the corporation. The frequent appearance of this topic at management conventions, in the journals and even in the popular magazines reflects the growing need for an articulate management ideology.

Finally, the new position of the business enterprise in society will demand considerable sharpening and broadening of management skills in the human relations area. Management will be increasingly judged not only for its economic efficiency, but also for the degree of self-fulfillment and dignity which it gives to those whom it directs. Management will need a more precise and richer insight into human behavior and will need to learn the most effective methods for motivating it.

Ownership and management are separated in large corporations; government interference grows; labor seeks decision-making role; public becomes more interested in business conduct . . .

The growing size, impersonality and complexity of the corporation is the other major aspect of the institutionalization of business. Evidence of this trend is to be found in such factors as the growing frequency of large-scale business mergers, the appearance of multiproduct enterprises, the tendency toward greater functional specialization of command within the enterprise and the very pronounced trend toward the "inbreeding" of top-level management. In connection with this latter point, it is interesting to note that the ratio of presidents of the large corporations who have served from twenty-one to thirty years with the company before taking command has increased from 9 per cent in 1900 to 48 per cent in 1950.

These trends in the internal organization of the business firm will have an enormous impact on the psychology of the future executive. Heretofore, the chief motive force behind the executive's devotion to hard work (whatever else happens, the 62-to-110-hour executive work week will not change), has been primarily economic. The executive has been largely moved by a desire to maximize profits and to produce goods. While this goal will not lose importance, the executive of the future will probably be more interested in the stability and perpetuation of the firm than in its expansion. His loyalty will be to the firm as an institution rather than as a maker of products or of profits.

Decision-making in itself will become a cooperative group effort. This may well have the effect of reducing the executive's drive to be an innovator and increase his desire to "swim with the tide." Caution, rather than innovation, may well prove to be the prevailing attitude. This tendency will be heightened, of course, as rising to the top of the organization becomes more a process of formalized promotions and less a matter of creative initiative. The executive's willingness to take risks may also diminish. A bureaucratic concern with the public reputation of the enterprise, the reactions of staff equals in the organization and the dominant concern for stability and solvency may lower significantly the executive willingness to "take chances." Concern for social approval and excessive identification with the enterprise as a whole may even lead to the acceptance of unprofitability in certain areas of the organization.

If a conclusion may be drawn from our discussion on how these two basic trends in our economy — automation and institutionalization — will affect the executive job of the future, it is that management faces a profound challenge to meet the new technical requirements of its profession and, perhaps more crucial, to define and assume its larger social responsibilities without losing its creative vitality in the solely economic realm. The success with which management recognizes and meets this challenge will largely determine the ultimate dimensions of the executive job.

A new philosophy of management is needed to spell out social and moral responsibilities of business to society . . . * * *

In these days all management personnel must be familiar with tax problems—Here is the best quick review we have found for the amateur on what taxes mean to business and industry . . .

What You Should Know About Taxes

Fred H. Pennington

SOME 4000 years before Christ, people in Egypt were paying some form of taxes. But the country's basic source of revenue was the income of the public domain. This was similarly true in the feudal days of Europe. It has been only late in history that governments have relied on taxes for the major portion of their revenue. Our present General Property Tax goes back to medieval Europe and the land rents and farm income of England and France, respectively. But nearly all of the other present myriads of taxes have been initiated since 1900. England passed an income tax in 1798. In the United States we didn't get income taxes until 1913.

Another new look in taxes appeared in the 19th Century. This new look was equity and uniformity. The establishment of democracies and the industrial revolution were responsible for this face lifting. The signing of the Magna Carta in the 13th Century and the English Bill of Rights in the 17th Century was partly the result of unjust taxes. Also, our own American Revolution was to a large degree due to unjust taxation without duly elected representatives to voice the opinion of the colonists. Taxes as a badge of freedom rather than a mark of bondage are a modern phenomenon.

How Do We Get Taxes?

A tax — in order to be a tax — must be imposed by the governing power through its lawmaking body or some legislative body.

If our representatives have done a good job, the tax should be able to meet certain qualifications. Adam Smith, 18th Century classical economist, set forth in his *Wealth of Nations* the principles of taxation. His four main principles are these:

1. Equity — Everyone should pay in proportion to his ability.
2. Certainty — The tax should not be arbitrary.
3. Convenience — Tax should be levied when taxpayer can best pay.
4. Economy — Take as little from the public as possible.

These qualifications have been reworded to fit present conditions and today read:

1. Social justice.
2. Consistency with economic goals.
3. Ease of administration and compliance.
4. Revenue adequacy.

The elements of taxation are:

1. Enforced contribution.
2. Exacted pursuant to legislative authority.
3. Proportionate in character.
4. Payable in money.
5. Imposed to raise revenue to be used for governmental purposes.

What are These Taxes?

Webster defines taxes as "a charge, usually pecuniary, laid upon persons or property for public purposes; a forced contribution of wealth to meet the public needs of government." Stated another way, taxes may be considered as the prices we pay for government and its services. We Americans have decided that we must have a great many governmental services. Some of us as individuals may not want, or may not receive many of these services, yet we are compelled to pay for them through taxes, because a majority of us through our democratic processes have expressed a desire for them.

Unnecessary and high taxes absorb income that would otherwise have been saved and made available for investment in new productive ventures.

What Do We Mean by Governmental Services?

I realize that you are constantly bombarded by figures and statistics in speeches and articles. I make no apologies for citing them here. I feel that it is the duty of every person closely associated with taxes and governmental affairs to seize every opportunity to present a factual picture to the people. Only to the extent that our people are well informed, can they intelligently express their opinions by vote or otherwise on these matters which so vitally affect our way of life.

Let's examine the governmental units and services we have. In 1952, there were over 100,000 different governmental units in the United States.[1] This total includes school and other districts, towns and townships, incorporated places, counties, and 48 state governments and the Federal government.

At the local level these governmental units provide free education, protection to persons and property, licensing of businesses, conservation of health and sanitation, streets and local public works, local legislative and judicial functions, and perhaps ownership of certain public utilities.

At the state level, our governments usually provide legislative and judicial functions, protection to persons and property, regulation of business, industries and occupations, conservation of health and sanitation, development and conservation of natural resources, highways and roads, correctional institutions, support of free schools and vocational education, higher education, parks, monuments and museums, and public welfare.

At the national level, I must confess that I cannot give you a clear, concise picture of the functions performed by the federal government. Jefferson said, "educate and inform the people." So, the federal government publishes an organizational manual. This manual only briefly outlines the functions of government in a volume of over 800

[1]Principal statistics from "Facts and Figures on Government Finance 1954-55," published by the Tax Foundation.

pages. It reflects that there are 142 principal departments and bureaus employing 2,500,000 civilians. These civilians receive three-quarters of a billion dollars in salaries each and every month. The Internal Revenue Service alone has 51,000 employees engaged in the collection, auditing, etc., of the federal taxes. These 51,000 employees of the Internal Revenue Service use office space equal to nearly four Empire State buildings. It prints each year about 700,000,000 tax forms and instruction sheets.[2]

Educating the people must have been easier in Jefferson's day.

Let's approach governmental services from another angle. An angle that Maxwell Anderson might call, "What price government?"

Last year, federal, state and local taxes amounted to a meager 90 billion dollars. That is about $600 for each of you and me and everybody in this country. Six hundred dollars will buy a lot of steaks, toasters and gasoline at your local retailers.

Of this total 90 billion dollars, the federal government got 75 per cent. The remaining 25 per cent was shared about equally by state and local governments.

Taxes today represent more than a quarter of the national product. If the trend since 1929 continues, taxes in 80 years will reach 100 per cent of the net national product.

But back to last year's 90 billion dollars of taxes. Where did the money come from? Over $5 billion of it came from taxes levied against petroleum operations and products.[3] Six per cent of the total taxes came from oil.

That 5 billion dollars when related to barrels of crude oil, represents $2.02 taxes on each barrel — and that $2.02 was almost three-quarters of the average price of a barrel of crude at the well last year. What price government for the oil industry last year?

Last year's $90 billion was collected by thousands of agencies through a hundred or more types of taxes, many of which are duplicated by the various levels of government.

Now let's get a little closer to home. We find that taxes will generally be the second largest item of expense on our profit and loss statements. This in itself is significant. But wait a moment, this is only the direct taxes we have paid. What about the so-called "hidden taxes?" We have all heard this expression and have a vague and uneasy feeling that something ought to be done about it. How much are you paying in hidden taxes? The plain truth of the matter is, you don't know and you can't find out. This is one of the main

[2]American Institute of Accountants.
[3]"Tax Economics Bulletin," July-August 1955, American Petroleum Institute.

The Author

Fred H. Pennington, comptroller of Magnolia Pipe Line Company and assistant secretary and manager of tax and governmental reports for both Magnolia Petroleum and Magnolia Pipe Line Company, is a native of Millville, Arkansas.

He began his career with Magnolia in 1923, in charge of automotive maintenance at the company's Beaumont refinery. About a year later he was transferred to Magnolia's general offices in Dallas in the producing accounting department, and in 1936 advanced to the comptroller's department. In 1950, he was promoted to comptroller of Magnolia Pipe Line Company and given the responsibility of manager of tax and governmental reports for both Magnolia organizations.

Pennington is a vice president of the Controllers Institute of America and is a member of the National Tax Association and the North American Gasoline Tax Association.

reasons why we should all step back and look at the total tax picture. The price you pay for goods and services includes taxes pyramided up on taxes. Some of the taxes you have never heard of. The price of a single product may include its proportionate part of ad valorem taxes, occupational taxes, transportation taxes, severance taxes, employment taxes, manufacturer's excise taxes, income taxes —these being imposed by different levels of government as the product passed from raw material, through many hands to the consumer. These taxes are not included in the "Tax Figure" shown on your profit and loss statement, nevertheless, you have paid for them. In this connection, if your supplier is not handling his tax affairs efficiently, or if his industry is bearing an unjust tax burden, you and your customers must either share or assume this additional cost. You cannot be complacent about a new tax being imposed on the other fellow, you may end up by paying it yourself.

Now some of us are more aware of taxes, or certain types of taxes than others.

For example, there is the story of the well-to-do business man who was playing golf at a swank country club. He lost a ball in some tall grass. The other members of his foursome waited while the man and his caddy searched for the missing ball. Finally, they became impatient and urged him to play another ball. "After all," they said, "the ball only cost you 75¢." "Is that so," the harassed golfer growled, "I had to earn $3.75 to get the money to buy that ball and I'm going to find it if it takes all day."

At first glance, this man appears to be unusually tax conscious. Well, that's not necessarily so. In recent years, it has become common for individuals and business firms to seek expert advice on federal income tax matters. This tax is so large and so obvious that we are all extremely aware of it.

To the top tax man, however, the subject "Taxes" means considerably more than just federal income taxes. That tax is heavy, and complex, and hundreds of articles, and tens of thousands of pages are written on the various phases of this tax each year. To the contrary however, very little, comparatively speaking, is written on state taxation, one of the most difficult problems of the tax man.

The state and local tax burdens on the oil and gas industry are sometimes greater than the federal taxes. Yet comparatively few tax institutes that are conducted over the United States each year ever include state tax problems in their programs.

But what about the hundreds of other federal, state and local taxes? Those that may or may not appear as such on the profit and loss statement.

Does our friend, the golfer, who is so aware of the impact of federal income taxes, exercise the same care to see that his business is properly handling these other taxes? Does he have within his organization, a man or department or departments sufficiently trained and informed on these matters to insure that he is exercising the same control on taxes that he exercises on other costs?

The various law and ordinance-making bodies make the tax laws, but the taxpayer must be the first to interpret them. He must determine how they apply to his operations. Then without the benefit of judicial determinations, attorney general's opinions and often without rules or regulations, he must make out his report and pay his taxes. The administrative agencies, to the contrary, usually have years of experience in which to use their hindsight. The taxpayer may overpay his taxes for years only to find that the law does not provide for a refund, or if so, that a statute of limitations bars a recovery of the overpayment. On the other hand, he may not believe that the tax applies to his operations only to find himself confronted with a large assessment with penalties and interest later on.

A recent article[4] had this to say:

"Less than a decade ago, a tax de-

[4]M. G. Paul, Jr., manager, tax department, Phileo Corporation (T.E.I.—1953).

DID YOU KNOW

1. **When present tax structure began?**
2. **What are elements of taxation?**
3. **How much was paid in taxes in 1955?**
4. **What per cent of taxes comes from oil?**
5. **What taxes pay for?**
6. **What are hidden taxes?**
7. **What 5 per cent of tax bill costs 50 per cent of administrative expenses?**

partment was a unique feature in all but the largest corporations. Yet today virtually every large and medium-sized company has found the services of a skilled staff indispensable to its successful operation.

"The evolution of the corporate tax department has been the inevitable consequence of its environment — the phenomenal increase in the volume and complexity of the tax systems which have inexorably encroached upon every facet of business activity, federal, state, local, and foreign.

"Progressive corporate management has proved alert to — government spending and tax policies of a magnitude almost beyond comprehension. It has been quick to appreciate the need for an internal tax staff adequate to administer all matters relating to taxation."

You might well ask, as to how best to be sure that the tax total as shown on the profit and loss statement was correctly arrived at.

No single pattern is known by which the different business firms mold their operations in dealing with the issues of taxation, even for companies of similar size and type. However, with respect to large integrated companies that have operations spread over several states, there is little, if any, room to debate the wisdom of setting up a tax department. This department should be under management level.

Generally speaking, here is what such a tax group should do:

1. Maintain a system of tax instructions to departments and advice to management.
2. Insure that the highly specialized tax know-how is so spread that its effect is felt on the entire decision making and operating functions of the company.
3. Consolidate reports on certain taxes, prepare full reports on others, prepare and file the reports and pay the taxes due therewith, on or before the due dates prescribed by law.
4. Handle the audits and examinations of such returns by representatives of the tax administrative agencies.
5. Handle all controversies and settlements with the taxing authorities.
6. Work directly with taxing authorities in developing procedures and forms. This should be done through accepted committee media, and as simply as is practicable.
7. Handle all inquiries concerning the company's tax matters from any source.
8. And last, and of the *utmost* importance, a tax group should have top legal talent available for counsel on all tax matters, including interpretations, controversies, settlements, etc., and to handle all matters concerning lawsuits.

Of course, every corporation should set up its own tax organization according to its own needs.

I would like to say that top tax men are not employed by corporations for the purpose of "chiseling" for the taxpayers, but rather to determine and pay only the taxes that are justly due under the laws. Some of the tax bases and items are clearly due, some are clearly not due, and some fall in the questionable area. It is usually in this area that the tax man more than pays his way by saving his company unnecessary tax costs. The size and type of a tax organization will, of course, vary with the size and type of business. The comparatively simple tax problems of a business operation can be increased tenfold by expanding into other states.

To give you an idea of just some of the things one tax group does, I would like to quote you some statistics we compiled at Magnolia a few years ago. These figures do not include either the reports or the tax payments of strictly ad valorem taxes, which are the function of a separate department.

Our two corporations, Magnolia Pipe Line Company and Magnolia Petroleum Company, are qualified to do business in about 20 states. Briefly, here are the facts concerning some of the matters our tax department handled for these two companies for a one-year period:

850 licenses and permits required to be obtained or renewed for their operations.

80 bonds (indemnity and surety).

Paid more than 40 different types of taxes and fees

To 44 differently styled collectors of taxes

In 38 different states,

Under 398 separate specific tax laws.

It was responsible for the preparation, execution and filing of over 3900 tax and other reports,

Which contained over 66,000 pages,

With 28,000 attachments,

And required 16,000 signatures (not including notaries), and

Paid out millions of dollars to the collectors.

This division enjoys an unusual balance in its relationship with company departments and governmental agencies. This is accomplished only through a high-level enthusiastic tax group adequately equipped in all respects as regards its functions, and with the full cooperation given it by a good legal department and all other company departments, and all governmental agencies.

I have quoted these statistics before and frequently encounter reactions of amazement or disbelief. They are easily substantiated. A national tax reporting service outlines 20 major types of state taxes. Under these major classifications there are 92 subdivisions. Just one of the 92 subdivisions may have 50 or 60 further divisions. Even these classifications, as numerous as they are,

grossly over-simplify our tax system. Many of these taxes may carry the same name, but have no common denominator. Each may be imposed upon a different type of activity, be computed in a different manner and employ different factors. So, for practical purposes, each may actually be a separate kind of tax even though captioned with a common name. The phrase, "There is nothing new under the sun," does not apply to taxes. Of interest here, we point out that we have a Texas Law that levies a tax on certain activities, but if some of these activities are exempt, the exemption is taxed. The general classification applied to the numerous federal taxes also tend to obscure the number and variety of such taxes.

Major Problems

Now let's get still closer to home and talk about some major problems and what can be done about them.

As long as spending increases, taxes must increase. This is a complete subject in itself.

The solution here lies with us all as individuals. Let's put it under the heading of citizenship. Here's what we can do.

We can take an active part in the selection of our elected officials. We can see that capable governmental officials are elected, pay them well, and expect capable and impartial administration. We must let these officials know what and how we want our money spent, what controls we desire, if and to what extent we want the government to engage in business. Also, we must, in a sense, regard the personnel in government as our own employees. Obtain the best possible personnel. See that they are well trained and efficient. Demand the same level of work that you expect of your own employees. On the other hand, treat them like you would your own employees. Do not generalize and condemn all government employees under one label simply because you know of certain conditions that must be corrected. Be specific and constructive with your criticism. If they are doing a good job, let them know. They are human beings, and they must take pride in their work, if they are to operate at top efficiency. You cannot attract capable young people into government service unless you can offer them a dignified career with most of the opportunities offered by private business.

It is our duty to support our government and pay for its services. But this duty does not require us to supinely accept any and all taxes, whether good or bad. It is also our duty to see that our legislatures and Congress pass tax laws that meet the principles of good taxation.

Another way we can reduce government costs is by cooperation.

Our lawmaking bodies in the making of laws, and our government agencies charged with the responsibilities of administering the laws, have enough trouble on their hands without any undue interference from taxpayers. Let's cooperate with them. If we don't like the laws that are passed, tell the lawmaking bodies about it, but don't complain to the tax administrators — they have the tremendous job of collecting the taxes under laws that you and I helped pass through exercising our prerogatives of voting.

What Can Be Done About Present and Future Laws?

First, tax legislation should be clearly drawn.

Poorly drawn laws, which are ambiguously phrased and difficult to interpret are the bane of existence for both the taxpayer and the tax authorities. The law may be so narrowly drawn that the administrator has no alternative but to demand reports and other procedures that are of no value to anyone. He has no power to make regulations to fit the various situations that inevitably arise. He must face the wrath of the taxpayers who are unjustly burdened, until enough pressure develops to have the law changed.

Let me quote from an attorney general's opinion to a tax administrator who questioned him about a major tax law. "... the definition of the term in this case is adorned with an intricate set of provisos and qualifications that excel all previous legislative ingenuity ..." The attorney general went on to say that thousands of cases would, therefore, have to be settled on an individual basis.

Laws must be broad —it is the small items that cause almost all of the costs to government and the taxpayer.

A person unfamiliar with tax administration would be startled by the disproportionate relationship between the time and effort spent on 95 per cent of the total tax bill and the time and effort spent on the other 5 per cent. It can be conservatively estimated that the problems and administrative tasks incident to 95 per cent of our total tax bill take only 50 per cent of our tax effort, while the other 5 per cent requires the remaining 50 per cent of our effort. Most differences arise over relatively minor items and amounts.[5]

Explanation for this stems from the fact that there are three tax classifications that an item may fall into. It may be:

1. Clearly taxable (or deductible)
2. Doubtful as to taxability (or deductibility)
3. Clearly non-taxable (or non-deductible).

Most of our problems will fall into the first or last category, and can be handled by a well developed administrative routine. Important as this area is, the tax due on these items is clear and there is little, if any, possibility of reducing the tax bill by working here.

Fewer problems will fall into the doubtful category, but it is this area that holds the greatest possible tax savings. The very doubt which makes this area the tax man's happy hunting ground also requires that he spend a large part of his time resolving those doubts in a reasonable manner. The manner in which he does this determines, to a large extent, his value to his employer.

Second, why not get experts to check laws for workability before passage? (Some committees already do that.) As an example, the New Mexico Special Fuel Tax law, that went into effect January 1, 1956, was tested by hundreds of hypothetical situations before a draft of the law was submitted to the legislature.

Third, there is something we can do about taxes in reference to "ease of administration and compliance." In the past, there has tended to be a condition of resistance and non-co-operation existing between tax commissioners and taxpayers. Fortunately, this situation is dissipating as both realize that very substantial savings can be made in working together to simplify the payment of taxes. Many hours of labor for both the taxpayer and the taxing government can be saved. These savings are possible if they will endeavor to reduce the amount of information needed for proper enforcement of the act. Likewise, the information should be reported in a manner that does not require complex workpapers and records. Evidences of efforts to do this are many. Industry committees have devoted many hours to developing uniform report forms and procedures that are practical and realistic. Generally, tax commissioners have shown a most co-operative spirit and have worked very closely with these groups.

In some cases, however, the desire

[5]American Institute of Accountants—"Helping the Taxpayer." "In 1953 there were about 67 million federal income tax returns filed with taxes paid of over $58 billion. 67 million returns and $58 billion are impressive figures. In 1952 we find that 758,000 of the returns filed required discussion at the various levels of the Internal Revenue Service, and only 636 cases were decided in actual courts of law." This points up to the fact that more and more we find the settlement of tax matters between the taxpayers or tax men and the tax collectors. State and local figures are not available, but it is believed that the percentage of cases requiring court adjudication is astonishingly smaller than federal. The states have also discovered that most matters can be settled through discussion rather than in the courts, and that most differences arise over relatively minor items and amounts.

to work with industry committees has been offset by laws that will not permit changes. The solution to this roadblock is close cooperation with our representatives to the various legislatures to secure the passage of uniform tax laws. Uniform laws are good because they simplify the work of the state and the taxpayer. Such uniformity would eliminate the necessity of setting up a completely different procedure for each state. True, under these laws any given state might stand to lose a minute percentage of its income from a particular tax. As practically all taxes are paid voluntarily, however, it appears that the savings possible in having no questionable details to police would probably offset any such sums lost.

Taxes — lots of taxes — are with us to stay. With this realization in mind, tax commissioners and industry tax men should strive continually to develop a spirit of friendly and willing co-operation. The benefits of such an atmosphere can be many. Not only will labor and money be saved, but goodwill and friendship will be developed.

I cannot help remembering the old days when controversies developed and, in many cases, lines were drawn and hard words exchanged but with little gained by either side.

Due to the complex nature of the law, it is inevitable that serious controversies will arise, many of which may only be settled by litigation. Such controversies should be handled on the basis of determining the intent of the law, rather than as a battle of taxpayer against government.

Today, it is gratifying to be able to say that time and men have changed things — now, capable, honest, hard-working and sound-thinking men from each side can and do meet and settle their differences in a sensible and friendly manner on most points.

I'll venture the thought that the government officials of Texas and of surrounding states, and their predecessors, would unhesitatingly attest to the fact that committees from such organizations of the petroleum industry as the Mid-Continent Oil & Gas Association, the New Mexico Petroleum Industries Committee, and other similar associations have met with the various taxing agencies of these states, many times at the request of the state. And together they have worked out many problems that in the old days would not have been satisfactorily worked out.

Now just a word about the enormous expense of making government reports, some of which are blank and some never read. Probably all of you have read about the Hoover Task Force Attack on Red Tape. A recent article in *Reader's Digest* deals primarily with the findings of the Hoover Commission's report on federal governmental paper work.

According to this article, there are enough records held in Federal buildings to make a file drawer reaching from the Pentagon to the Kremlin — 5000 miles — each inch of which costs $2.00 a year to operate. Among them were nearly a million reports reporting that there was nothing to report.

Well, I'm real glad that I can say, that with respect to all the states in this region, the committees of industry have worked with state administrative officials over the past decade along the same lines as Hoover is working on the federal reports.

These things you must remember . . .

1. **Taxes have reached such gigantic proportions that there is no room for inefficiency in handling them.**
2. **Legislators who are responsible for tax assessment and tax spending should be chosen with care and should be kept aware of our judgment regarding taxes.**
3. **The public should be kept informed about tax legislation and regulation so that they will be alert, also, to taxes detrimental to smooth operation of business and industry.**
4. **The government's job of collecting, spending, and regulation of taxes should be fairly and efficiently done without waste of time, space, or funds. We should be aware of what is going on and quick to point out savings of our money, which is pooled for the protection and welfare of the nation as a whole.**

Impact of Taxes and Governmental Reports

We have already observed that many taxes, regardless of whether imposed directly upon marketing activities or upon other allied departments, eventually comprise a substantial portion of the cost of the product.

The power to tax is the power to destroy, and it is possible for your product to be taxed out of the market, particularly when the margin of profit is extremely small.

Likewise, an undue burden of complicated reports and record-keeping requirements may increase your costs prohibitively.

You may have experienced, or heard of many small producers who recently incurred legal and accounting costs in complying with Federal Power Commission orders that were way out of proportion to the revenue they derived from their sales of natural gas.

Even direct taxes on your products are sometimes difficult to determine. We recall specific instances of where, due to the difficulty of determining whether or not a certain product was subject to a certain federal excise tax, bids were received from some suppliers that included the tax, and bids from others that did not include the tax. Naturally, the low bidders and the ones who got the contracts were the ones excluding the tax.

Frequent audits of federal excise taxes by examiners of the governmental agencies who are expert on such taxes, and a capable tax department are both necessary to eliminate what sometimes turns out to be unfair business competition.

Conclusion

Let us sum up in this way. Government, government spending, government controls and taxation are inextricably bound together. They have all reached such gigantic proportions that there is no room for mediocrity in any phases. Therefore, in a sense, we must have many types of experts.

Our own businesses must have competent tax groups to cope with the increasingly complex taxes and regulations.

We must be an active and informed people.

We must do what we can to elect capable legislators who understand our problems and let them know to what extent and in what manner we desire to be governed.

We should all urge that government officials be experts and cooperate with them.

We who work every day with tax matters should keep in mind the importance of informing the public in every way we can about the great impact of taxes on our economy. ★ ★

Oil Companies Bounce Back From Third Quarter Doldrums

Increase in business was easing when Middle East oil was squeezed by Suez closure and by Iraq pipe line blowup . . . Now prices are firming and demand outstrips transportation facilities. . . .

Ernestine Adams

THE year 1956 will have another record high operating income and earnings for the oil industry. Although the third quarter shows a leveling off of increase in gross and net income for oil companies, the shortage caused by slow-down of distribution in the Middle East is bringing an up-turn in the fourth quarter.

The table on financial reports (opposite page) reveals one aspect of the oil industry that each year grows more obvious— that is, the reliable increase year by year, which is not too greatly influenced by general economic conditions. A year ago oil earnings were up 17 per cent above 1954 (The Petroleum Engineer, December 1955, Page E-22), when the national rise was twice that much. This year net income over the first three quarters shows a 17 per cent rise over 1955 but overall corporate profit margins were weakening.

The third quarter does show a slip in earnings increase. Percentage increase for 1956 was only 13 per cent above last year for the same quarter. Total income for the three quarters was up 12 per cent; the third quarter had dropped to a 10 per cent increase. The first two quarters showed revenues up 13 per cent.

In the third quarter, revenues rose for most companies; only 5 fell below 1955 in gross income. There were 17 firms that could not hold the fast pace set in earnings for the third quarter and dropped below last year in net return.

Atlantic Refining, Clark Oil and Refining, Colorado Oil and Gas, Maracaibo, Universal Consolidated and Woodley Petroleum ran counter to the trend. All made more than 50 per cent gain over the third quarter of 1955.

For the first three quarters only one company did not increase revenues over 1955. Of the 70 companies, Three States Natural Gas had 2 per cent less gross income from operations than last year and all the others showed increases. Eight firms were behind 1955 in net earnings.

Not only has the Middle East situation influenced the oil market but in general the market has shown more firmness since the election. Gross national product, which gives us a rough estimate of economic activity, has topped $400 billion and continues on the rise.

Industrial production is 3 per cent ahead of last year in spite of the toll taken by the steel strike.

Sales of 1957 automobiles have already made a mark in the fourth quarter and manufacturers have scheduled a 7-million car output for the year.

The new Federal highway program got off to a good start this year. As it speeds up it will mean a growing demand for materials from the industry for highway construction and for motor fuel for increased driving.

As a whole the United States has never been so prosperous. Some segments fell behind the general advance but the overall picture is rosy.

One reason is the expenditure for capital goods. Business and industry have shown complete confidence in the expanding economy and belief in a political climate that will back private enterprise.

Early estimates this year pointed to a $35 billion investment in new plant and equipment for all business.

This may well be too low. Our mid-year appraisal of the petroleum industry indicated a 10 per cent increase in capital expenditure estimates over the January plans. This put investment by U. S. companies here and abroad at $7.4 billion in 1956. Chase Manhattan earlier this year estimated that petroleum companies both U. S. and other nationals in the free world spent more than $8.2 billion in 1955.

There is every indication that 1957 will see a rise in this fantastic sum. The Suez situation has shown, as no argument ever could, the need for development of oil and gas resources in the Western Hemisphere. It will require giant capital to keep a surplus production capacity like the one that serves us so well in the present critical time.

Financial consultants have not agreed on the effect of the Middle East distribution bottleneck on various companies. Standard and Poor have these estimates for international oil companies interests: Gulf will earn 52 per cent from Western Hemisphere operations; Socony Mobil will earn 58 per cent, Standard of California will earn 61 per cent, Texas Company will earn 69 per cent, Jersey Standard will earn 74 per cent in Western Hemisphere operations during 1956. In other words, all U. S. companies have greater revenues on this side of the world.

One investment counselor reports that domestic crude-producing companies will benefit in coming months from larger output. At the same time international oil companies will not be badly hurt because price firming will improve earnings in the Western Hemisphere.

Another observer points out the most vulnerable spot in any financial report of a company that produces oil. Current earnings are overstated as profits because they are made on reserves discovered at low cost many years ago with present replacement costs far higher. Only an increase in depletion percentage can offset this weakness in the financial picture together with a higher price for crude oil.

The overdue price rise is coming soon because of the Suez bottleneck. To obtain a needed increase in depletion allowance the industry must do better communicating that it ever has before. * * *

Miss Adams is management editor.

Financial Oscars

In its survey of corporate reports this year, *Financial World* chose the following for "Best of Industry" awards. For large integrated petroleum companies the bronze oscar went to Continental Oil Company. Runner-up was Creole Petroleum Corporation and next was Standard Oil Company (Ohio).

In the small independents category, Texas Pacific Coal and Oil Company drew top honors. White Eagle Oil Company was next and Plymouth Oil Company was third. This is the sixteenth annual survey of financial reports made by the magazine. A total of 5000 annual reports were considered this year in the international competition and 1700 qualified for the final screening. There are 100 industrial classifications.

FINANCIAL REPORTS FOR FIRST THREE QUARTERS*

Company	Third Quarter Gross Income $1000 1956	1955	% of 1955	Third Quarter Net Income $1000 1956	1955	% of 1955	First Three Quarters Gross Income $1000 1956	1955	% of 1955	First Three Quarters Net Income $1000 1956	1955	% of 1955
Amerada	26,080	24,544	106	5,920	5,821	102	79,416	74,951	106	19,482	18,017	108
Am. Maracaibo	2,236	2,074	108	837	627	133	6,775	5,733	118	2,057	1,635	125
Anderson-Prichard	17,320	15,667	111	1,447	1,301	111	50,837	42,854	116	4,229	3,216	131
Argo Oil	2,969	2,771	107	1,259	1,085	116	9,047	8,411	108	3,342	3,446	97
Ark. Fuel Oil	39,055	36,684	106	2,012	1,900	106	119,075	109,410	109	5,746	5,731	100
Ashland Oil[12]	—	—	—	—	—	—	279,950	245,881	113	13,504	10,106	133
Atlantic Refining	124,240	114,809	106	10,542	5,485	192	401,290	375,465	107	32,691	24,368	134
Astec Oil	541	459	118	101	116	87	1,546	1,441	107	387	337	115
Barber Oil	—	—	—	—	—	—	—	—	—	492	14,444[11]	—
Bishop Oil	693	616	113	108	116	93	2,073	1,607	129	308	274	112
Chicago Corp.	—	16,288	—	—	1,720	—	—	47,477	—	6,733	5,323	127
Cities Service	223,677	213,206	105	13,086	8,951	146	721,608	672,385	107	43,491	34,300	127
Clark O & Ref.	20,229	15,612	130	722	415	174	57,034	42,758	133	2,021	1,176	172
Colorado O & G	7,573	6,673	118	840	308	273	22,310	17,896	125	1,996	942	212
Continental Oil	143,836	136,427	105	13,593	12,283	111	431,234	392,992	110	39,142	34,455	114
Crescent Corp.	—	—	—	—	—	—	—	—	—	496	2,168[3]	23
Delhi-Taylor	12,872	14,920	86	(342)	450	—	41,185	39,919	103	1,024	1,761	58
Douglas of Calif.	—	6,457	—	—	116	—	14,471[1]	11,959[3]	121	432[3]	132[3]	327
Esson Oil[10]	—	—	—	—	—	—	4,295	3,476	124	905	540	168
General American	—	—	—	2,115	2,264	93	24,017[4]	23,420[4]	103	8,738[4]	7,678[4]	114
General Crude	3,218	3,103	104	734	843	87	9,592	9,582	100	2,503	2,768	90
Getty Oil	—	—	—	2,297	1,950	118	12,207	10,073	121	6,274	3,383	185
Gulf Oil	—	—	—	68,197	53,416	128	—	—	—	206,269[1]	145,287	142
Hancock Oil	13,255	12,611	105	1,531	1,688	91	40,146	35,343	113	5,280	4,669	113
Honolulu Oil	10,767	8,955	120	3,726	4,133	90	31,543	26,275	120	10,588	10,328	103
Husky Oil	—	—	—	—	—	—	30,980[4]	23,588[4]	130	2,071[5]/[4]	717	275
Kerr-McGee	—	21,040	—	—	1,173	—	90,441[4]	45,529[4]	199	4,680[4]	2,485[4]	188
La. Land & Expl.	6,363	6,290	99	3,426	3,460	99	19,374	19,021	102	10,486	10,393	101
Leonard Ref.	—	—	—	—	—	—	27,252[3]	26,183[3]	104	1,248[3]	952[3]	131
Macmillan Pet.	—	431	—	—	109	—	1,474	1,032	141	153	115	133
Maracaibo	561	471	119	136	79	172	1,681	1,448	116	414	260	159
Midwest Oil	4,211	3,579	118	1,618	1,492	108	12,137	10,560	115	5,003	4,502	111
Monterey	4,259	4,600	93	304	414	73	13,596	11,035	123	1,009	829	122
Nortex O & G	503	94	535	81	(23)	—	1,521	746	204	252	102	247
Ohio Oil	65,257	64,291	102	9,030	9,642	94	205,975	190,975	108	30,296	29,193	104
Phillips Pet.	252,117	230,388	109	20,005	22,614	88	760,071	660,405	115	71,570	65,189	110
Plymouth Oil	—	—	—	—	1,315	—	—	—	—	5,984	5,210	115
Pure Oil	116,475	119,145	98	8,384	8,569	98	367,761	358,478[13]	103	26,210	24,650	106
Quaker State	11,402	12,289	93	476	710	67	39,701	37,080	107	1,669	1,918	87
Richfield Oil	64,237	58,417	110	6,237	8,030	78	187,567	182,164	103	20,769	22,665	92
Seaboard Oil	12,058	10,491	115	2,556	2,056	124	35,021	31,570	111	7,530	6,105	123
Shamrock Oil & Gas	—	—	—	—	2,056	—	39,615	31,424	126	6,631	5,538	120
Shell Oil	401,001	373,797	107	20,703	31,149	99	1,192,575	1,087,262	110	100,144	85,646	117
Signal O & G	—	3,967	—	2,477	2,427	102	—	10,560	—	7,045	6,507	108
Sinclair Oil	277,793	264,129	105	20,928	18,337	114	874,496	799,720	109	66,032	56,138	118
Skelly Oil	61,626	58,052	106	7,805	7,992	98	187,464	169,257	111	22,345	22,815	102
Socony Mobil	—	—	—	59,505	50,758	117	—	—	—	183,276	150,347	122
Standard Calif.	396,897	358,455	111	68,305	56,930	120	1,137,158	1,008,329	113	190,355	166,272	114
Standard Ind.	462,334	443,062	104	39,087	37,819	103	1,410,244	1,308,047	108	114,991	102,783	112
Standard Jersey	1,881,000	1,627,000	116	211,000	179,000	118	5,375,000	4,698,000	114	603,000	523,000	115
Standard Ohio	89,948	84,639	106	6,706	6,183	109	270,716	247,395	109	20,159	16,306[9]	124
Sun Oil	182,880	168,389	109	14,658	12,644	116	533,366	492,052	108	39,797[3]	37,051	107
Sunray Mid-Con.	—	73,458	—	—	9,907	—	—	220,967	—	31,400	27,706	113
Superior Oil[14]	—	—	—	—	—	—	90,206	80,518	112	5,041	3,395	148
Texas Co.	530,811	477,841	111	69,341	64,933	107	1,557,716	1,389,248	114	207,429	189,767	114[6]
Texas Gulf Prod.	—	4,077	—	—	1,742	—	—	12,134	—	—	5,438	—
Texas Pacific C & O	5,975	5,467	109	1,740	1,644	106	17,866	17,248	104	5,506	5,766	95
Three States Natural Gas[7]	1,028	950	108	(77)	(44)	—	3,278	3,358	98	(331)	20	—
Tidewater Oil	128,962	115,008	110	8,492	9,234	92	385,123	354,292	109	30,091	27,256	110
TXL Oil	—	—	—	—	—	—	—	—	—	3,064	2,338	127
Union of Calif.	106,272	96,354	108	12,489	8,796	142	296,200	274,247	109	26,107	25,094	104
Union O & G of La.	6,911	5,747	120	181	734	25	20,471	17,035	118	2,176	1,350	161
Universal Consol.	1,960	1,339	146	706	399	177	5,881	4,039	146	2,461	1,407	176
White Eagle Oil	—	3,084	—	—	120	—	—	7,558	—	—	(37)	—
Wilcox Oil	2,235	2,051	108	148	242	61	6,536	6,281	104	690	672	103
Woodley Pet.	1,562	1,199	129	577	363	159	4,356	3,157	138	1,541	846	182
TOTALS	5,721,776	5,204,601	110	733,555	647,256	113	17,533,838	15,696,800	112	2,266,426	1,945,301	117

*Estimated
( ) loss
[1] Includes earnings of Warren Petroleum Corp. since March 1, 1956.
[2] For 6 months ending September 30.
[3] Capital gains income $302,310 in 1956 and $1,264,959 in 1955.
[4] For fiscal year ending June 30.
[5] Includes capital gains income of $560,556.
[6] Excluding capital gains income of $8,184,530 in 2nd quarter 1955.
[7] For fiscal year ending May 31.
[8] Includes capital gains income of $1,602,000.
[9] Nearly all capital gains income from sale of Deep Rock properties to Kerr-McKee.
[10] For fiscal year ending July 31.
[11] Includes $14,160,571 from liquidation of American Republic Corp.
[12] Includes $1,041,000 capital gains income.
[13] For fiscal year ending September 30.
[14] For fiscal year ending August 31.

Four Clues to Personnel

Current shortages of skilled help have caused companies to take a second look at their own work forces, seeking four leaf clovers that they've "overlooked before." So says Eugene J. Benge, management engineer and author. "Automation is progressing so fast," Benge says "that we've got to develop skilled men and knowledgeable supervisors—and quick." The new look is in four directions:

1. **The search-for-talent,** using aptitude tests, supervisory ratings and interviews.

2. **Upgrading of technical jobs,** to insure that technically trained men are not wasting their talents on clerical or routine duties.

3. **Specialized training of skilled workers** through repetitive impact methods, and following analysis of the knowledge, sensory skills and muscular coordinations needed.

4. **Key man development,** which in addition to normal training, involves improvement of physical factors, social relationships and attitudes, spurred on by both financial and non-financial incentives.

Tenth of a series

What Management Can Do To Improve Communication

Dennis Murphy

A breakdown in communication is just as costly, dollar-wise, as the breakdown of a machine, pump, or pipe line. Although we don't compute the costs of communication failures, we know they're mighty large. Yet we can actually prevent breakdowns in communication, whereas we can't avoid them in machinery.

Let's talk about communication within the company rather than with the outside public. And let's assume the normal use of oral and written messages such as the company's magazine, bulletins, annual report, and the like. Now let's come clean: isn't there a lot of room for improvement?

Top Management Sets the Tone

By "management" we mean everyone in a supervisory capacity. This includes not only officers and executives who formulate aims and policies, but also every other supervisor who helps to carry them out on the executive, departmental, and first-line levels. And success or failure of communication, in the final analysis, depends upon those supervisors nearest to the workers themselves — that is, upon group leaders, section heads, and foremen who directly manage the smaller units of employees.

How can we bridge this silent gulf between managers and workers? How can we democratize the company — so management will consider labor cooperative, and labor will consider management communicative?

This seems the crux of the problem, and its solution is up to the *whole corps* of managers, not the top men alone. They can improve the communication in all directions—and they're doing it!

Some Causes of Poor Communication

1. **Attitude of Employees.** Some older executives inherited a hush-hush attitude from the nineteenth-century tycoon who was the sole owner of his business and ruled it with a hard hand. Today, most companies are multiple-owned and multiple-managed. But some managers, even those who consider themselves progressive, withhold a lot of information from employees.

A secretive policy about confidential matters, of course, is valid and necessary. As in a family, parents share some knowledge that children are not let in on, and all of them share information that neighbors and in-laws are not told. But the wholesale policy of telling rightful members nothing is autocratic, paralyzing, and dangerous.

Messages get twisted, diluted, and distorted as they pass through normal channels. Some bosses sift facts and feelings; others slant them. Often a boss who tells his men nothing will stoutly resent *his own boss* for not telling him everything! And many a boss thinks talking with his men lowers his dignity, wastes time, fosters complaints, or invites misinformation.

Poor communication is often *intentional*. Some self-important little supervisors keep others in the dark — to build themselves up as storehouses of indispensable news. "Why didn't you come to *me*?" Another type says he doesn't have time to communicate. He's a liar. Either he lacks leadership, or he hasn't mastered his job. In either case, he's a liability because his lack of communication harms the organization.

The attitude of workers is just as important as that of managers, if not more. Workers are often silenced by rank, title, salary, education, physical surroundings, and wordly possessions. Any feeling of superiority or inferiority hampers communication, and the first step toward solving this problem should come from the man with the "seeming" advantage.

Employees will renege in passing adverse facts upward, too, and usually sugar-coat them to soften the blow. Some won't report bad news at all unless they know they'll get caught or catch hell if they don't. Yet on a recent questionnaire 140 out of 200 executives *said* they got accurate and uncolored information from the men who report to them.

On the other hand, some employees like to paint facts worse than they are; despite their show of sympathy, they enjoy

Dr. Murphy is administrative assistant, Service Pipe Line Company.

doing this because they get a satisfaction out of releasing their own opposition to their boss.

Workers have a right to share appropriate information. Mistrust begets mistrust. When managers won't share allowable facts that further the common purpose of the company, workers become interested in little except the time clock and their pay check.

They fail to realize that *they* can never prosper unless their company and colleagues *also* prosper. When communication fails or breaks down, it leaves a void that separates interests of the workers from interests of the company. If it does, look out! Things can happen then.

2. **Increased Size of the Organization.** As a firm grows, its informal communication usually decreases while its formal written work increases. This is natural and inevitable. The head of a small business can call all his men together for a daily meeting; but a top manager in a large company knows only a few men on the higher levels — and may never even see the rest.

Likewise, as a company grows, physical distance grows between top management and workers. More levels of middle management — where communication so often breaks down — are added until some firms have 15 or 20 levels, more than we find in the army.

In the last 25 years, or even 10 years, business and industry have undergone tremendous changes. Individual fortune-making is becoming more rare, while the number of stockholders is increased by reducing the price of shares so that the lowest-paid worker can buy them. Far-seeing companies help their employees do this and offer many other benefits to boot.

Study the facts

Decentralization of large companies is one attempt to shorten the physical distance between top management and workers, promote better communication, and gain more democratic operation. As Benjamin Fairless of US Steel says, our people "expect American business to be run in the long-range interests of the public."

3. **Increased Complexity of Work.** Business and industry have always been more authoritarian than our schools, churches, and government. In some matters business should remain authoritarian and not await the vote of a majority — as in planning, financing, expanding or curtailing production, hiring certain employees, and the like.

But that's all the more reason why a company should be democratic in matters where the workers' ideas are appropriate and valuable. How can we reconcile the freedoms of expression our workers have grown up in — at home, in school, and in society — with the restrictions they find in business? Our future managers should probe these problems of communication, because whoever controls communication in the future — will control!

Size, complexity, and specialization make it hard for a worker to comprehend a large organization or understand his part in it. He may even lose interest in expression that answers his need or his creative urge. Every other man seems like a technical expert — an efficiency engineer, cost accountant, advisor, or inspector of some kind.

Tending to see work only from his own point of view, a man can grow indifferent to the human touch. Result: lack of communication. We can also communicate like hell and get nothing done — depending on the people we work with. *And some people are by nature very uncommunicative!*

Perhaps we ought to question some of our business traditions. Do our "regular channels" really do the communication job as they should? Or do we need more direct avenues? How can we find out quickly what's going on up or down the line without short-circuiting somebody? Is fear of undercutting the supervisor's authority holding us back in examining the channels critically? Would more channels help make more flexible and circumspect supervisors?

What effect will automation have on the complexity of our work? What effect will automation have on intracompany communciation? Is it possible to have too much communication? If so, how can we get more satisfying participation without losing control or morale? We don't know the answers, but we raise these questions to stimulate further thinking.

Reasons for Better Communication

Some values of *upward* communication are that it: (1) forewarns top management about what policies are acceptable, and when; (2) shows whether men understand the meaning of directives; (3) gives workers a release for emotional tensions and pressures; and (4) allows them to offer valuable ideas to their supervisors.

Some values of *downward* communication are that it: (1) helps all managers' authority to be accepted and obeyed; (2) shows in a democratic way what common targets to aim at; (3) expresses a friendly interest that builds morale everywhere; (4) evokes cooperation and helps solve problems.

All employees, managers, and workers alike, need more and better communication. Managers need it — to live longer, if for nothing else. Medical advisors say businessmen under pent-up emotional strain are the most frequent victims of ulcers and heart attacks. Instead of inhibiting their feelings continually, they need to "blow up" occasionally—as a safety valve for their pressures — not at persons, but at conditions and things! Sometimes they're as meek as Moses at work, but petty tyrants at home. That's bad.

Workers, likewise, have an immense need for *self-expression*. They also need the feeling that they "belong," the sense of *participation* that's so highly important. In addition, they require a *catharsis* (or a purge) for personal tensions on their jobs. And when their opinions and suggestions are welcomed, they find a *creative outlet* for their ideas. These four needs for employee communication should be enough to convince any executive of their tremendous value.

How Management Can Improve Communication

1. **Through Communication Training.** Any mention of improving communication implies, unfortunately, that it's not up to par. I don't want to imply this, because some companies may already enjoy all the communication they desire. Nor do I wish to imply that my own company has gone as far as I indicate, because it hasn't! But if improvement is our aim (as I think it ought to be), a few suggestions may prove fruitful for a sizable organization.

Many factors, of course, should be considered to determine the need and extent of communication training: size of the company, the nature of its product or service, its competition

in the market, its personnel, and so on. The need for communication training, for example, may vary from none in a small cannery of 40 employees to much in an insurance company of 4000 employees.

The *first step* is for top management to assign the training job to some existing unit or create a unit that will work with all departments. All of management should support this training fully and check its results. The logical checks are natural feedbacks, opinion surveys, questionnaires, and — best of all — clearer thinking, better speaking in conferences and committees, simpler memos, friendlier letters, and more readable reports.

Much depends upon the supervisor of this training. Skilled in all forms of communication, he should value common sense more than college degrees or test scores. Since he will work with adults of various capacities, he should adapt instruction to the individual. Always mindful of the company's policies and purposes, he should *show* how as well as *tell* how.

He'll need plenty of patience, lots of tact, a sense of humor, and a sound working knowledge of psychology. If he can stimulate employees to think, read, write, and speak as they never dreamed they could, he's all right! For his main purpose is to draw out their best efforts for their jobs, and to make those with little formal schooling realize *how* they can live, rich, happy, useful lives.

The *second step* is to set up courses in all communication skills — thinking, observing, writing, reading, speaking, and listening. These courses should reach those employees first who need them most, but they're fine morale builders for *all* workers, especially those on routine jobs such as the operation of machines. Courses can be like "coffee breaks" — yet more valuable because learning is fun! Keep them laughing while they learn! According to Dr. Gallup, the unhappiest of all people in America are factory workers in our large cities.

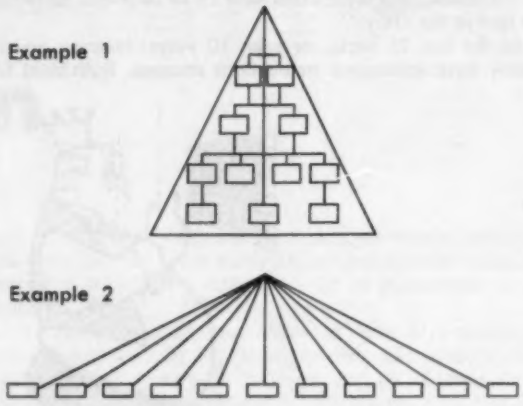
Employees who attend a one-hour class three times a week on company time and money must, of course, make up their regular work. Their work always comes first, but they learn short-cuts and simpler methods in communication that save time. Because rush jobs and emergencies affect attendance, courses should be properly timed. Short 4 to 6-week courses that reach employees frequently are less likely to be disrupted than longer ones.

Courses should be kept going, year in and year out. Some of the most profitable ones are those in business letter writing, technical report writing, word study, vocabulary building, sentence structure, punctuation and spelling, principles of speech, public speaking, speed reading, reading great books, detecting fallacies in thinking, and creative thinking on the job.

Quite a large order, isn't it? Each company needs to determine how much its communication training should be stressed, and where. The supervisor of this work may need assistants; if so, trained employees with a first-hand acquaintance of inside roadblocks may prove more valuable than imported assistants.

2. **Through Reorganization.** Recent research indicates that our business communication is often influenced as much by company setup as by human personality. An employee in a strategic location where many channels converge is frequently a person others regard as a leader. Knowing what's going on is a requirement of democratic leadership. And since horizontal communication is easier to achieve than vertical, a good many managers advocate rearrangement of the company structure to step up communication.

Sears Roebuck, for example, has for years organized its retail stores along two general patterns: (1) the centralized and compact pyramid with many levels of rank, and (2) the spread-out and horizontal fan with more emphasis on delegated authority. These two figures will show roughly the difference:

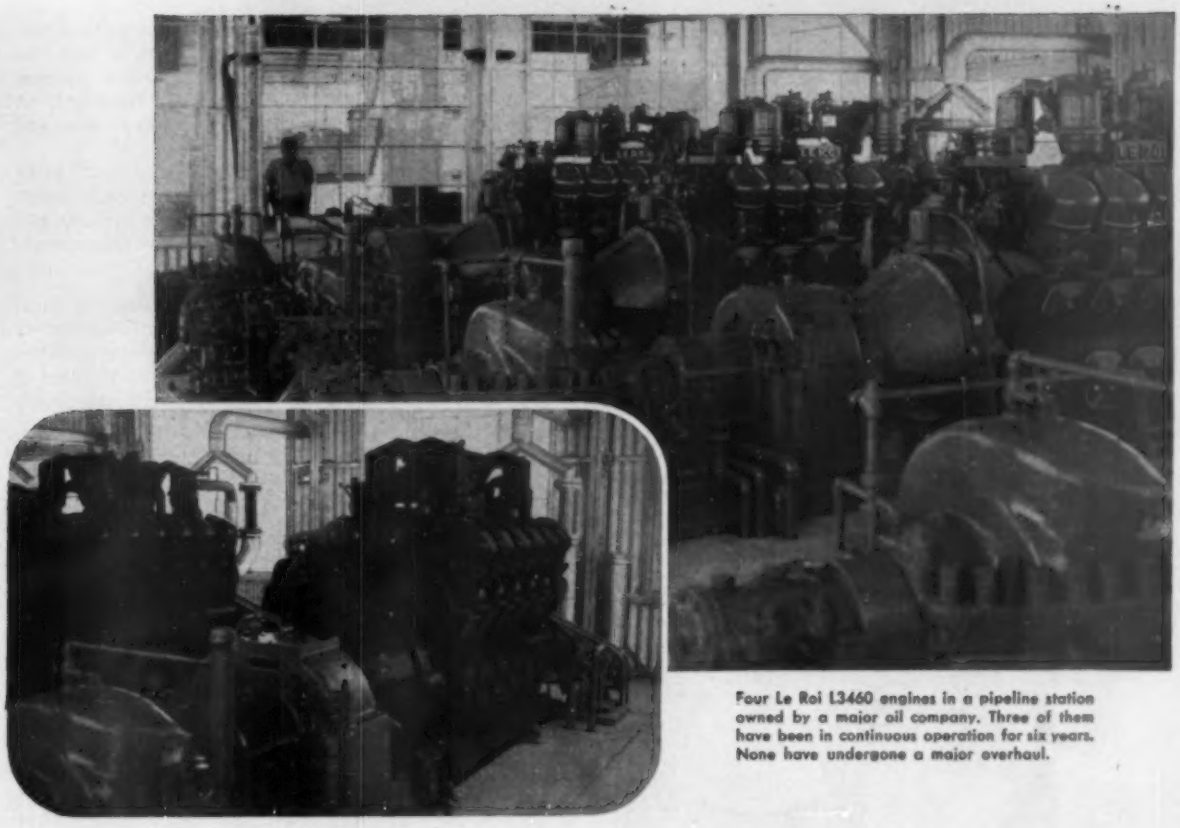


Questionnaires by Sears on both types of organization showed that the spread-out type rated higher in morale, in communication, in promotable young men for executive positions, and in flexibility needed to adjust to sudden change or crisis. This type also came up with about the same efficiency and number of sales as the pyramid type. But the surveys showed that men who had been conditioned by the pyramid type didn't like the looser setup, and vice versa. As James C. Worthy of Sears says, "To change the structure, you have to change the guys."

On the other hand, some men believe a large company fares better with more levels of authority, not fewer. Some firms like Du Pont & Company have thirteen levels, about the number we find in the army, and fare as well as Sears with less than half that number. Forty-two executives report to one boss at Sears; the span of control is much tighter at Du Pont.

Professor Alex Bavelas of MIT and others elsewhere have experimented with communication in both the traditional pyramid and horizontal structure. Those who were allowed to communicate on the same general level proved happier in their work than those forced to buck the "regular channels," even though not quite so efficient. Those working out their problems on a common level showed more adaptive ability and survival power. In the long run, democracy came off better than the autocracy with "its great big wall."

To shorten the vertical line is to make communication more direct. This shortens physical distance, minimizes the stress on rank, reduces the number of bosses, and lessens organization complexity — four known barriers to communication.



Four Le Roi L3460 engines in a pipeline station owned by a major oil company. Three of them have been in continuous operation for six years. None have undergone a major overhaul.

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Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting —that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

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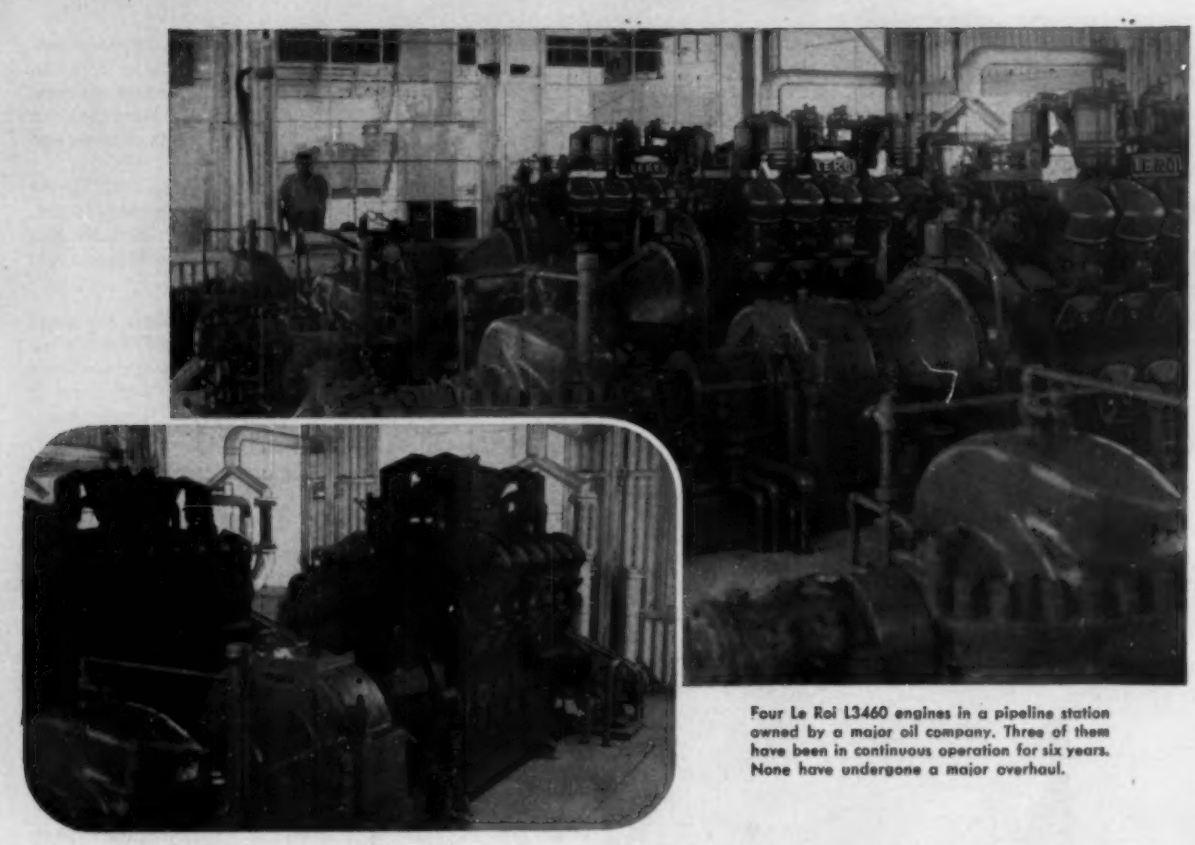

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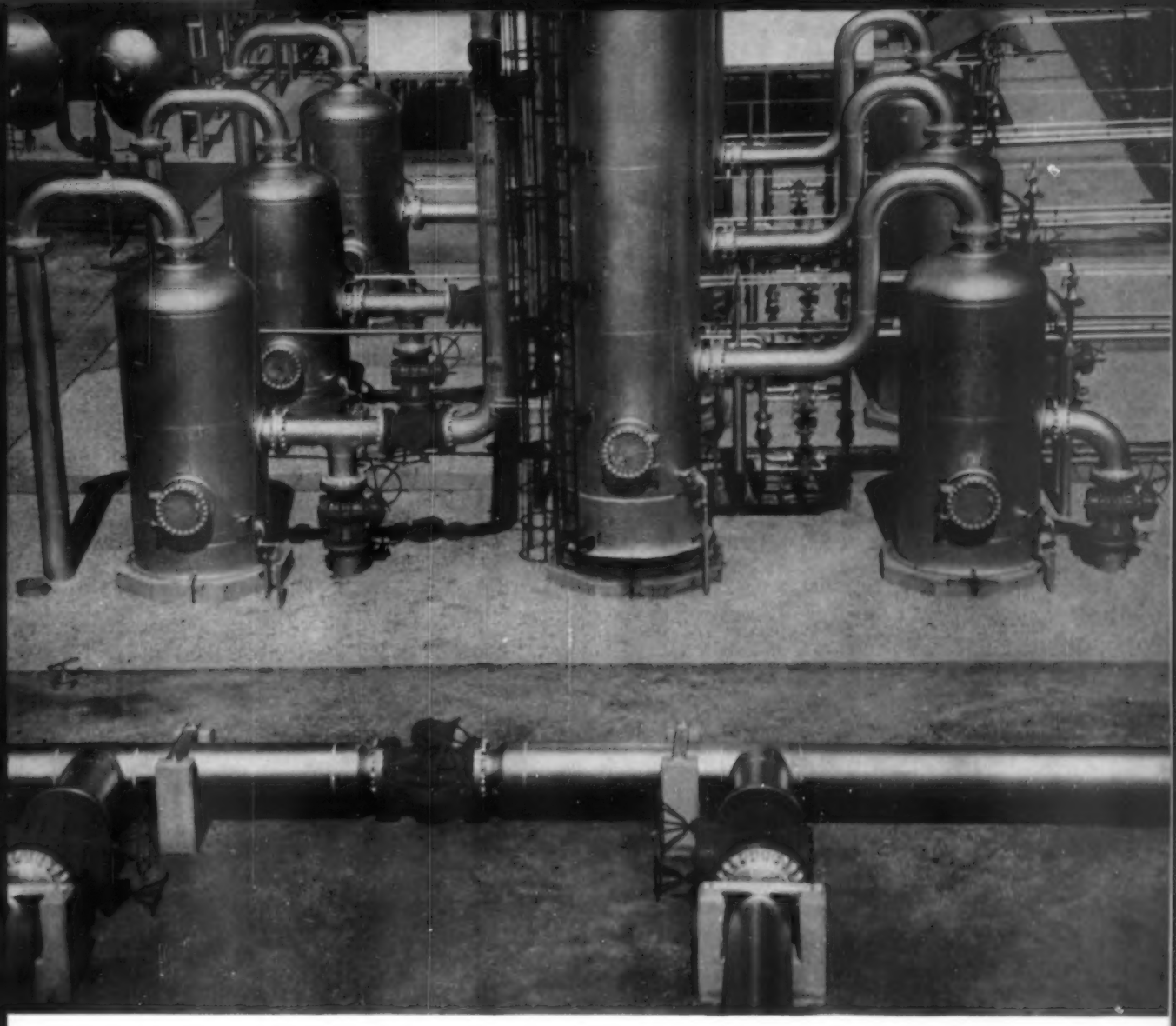

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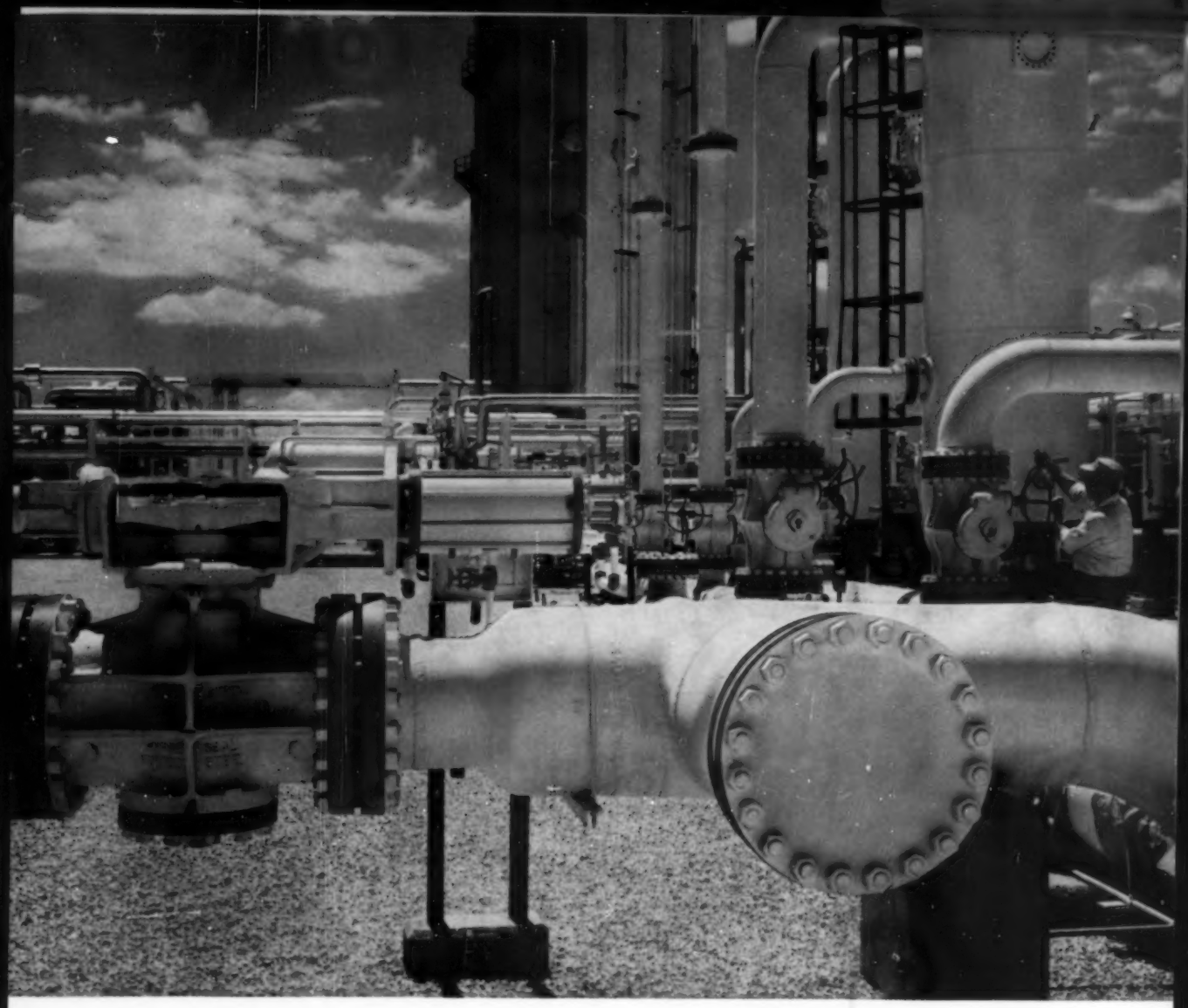

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ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

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View of Transcription Center at the modern new offices of the Standard-Vacuum Company in White Plains, New York. In the immediate foreground are some of the 24 central recorders which record dictation from 245 remote dictating stations.

In center is the switchboard that automatically connects any one of the remote dictating stations with a recorder which is not in use. In the background girls in the transcription center type letters and memoranda.

A minute adjustment is made in the maze of wiring that makes up the heart of the telephone dictation switchboard. It automatically connects any one of the 245 remote dictating stations with one of the 24 central recorders which is not in use when the receiver is lifted.

Speeding Up Office Communications

Standard-Vacuum has put mechanics of dictation and inter-office contact on an assembly line basis . . . files are delivered by a completely automatic pneumatic type system . . . Takes trained people to run this system

THE most modern dictation and inter-office communications system in the world has been installed in the new White Plains, New York, office of the Standard-Vacuum Oil Company.

A PhonAudograph telephone dictation system with 245 remote stations, a specially designed switchboard which automatically selects a free recorder for the user, and the first completely automatic pneumatic tube system for the delivery of files within the organization — all this means that both the printed and spoken word move very fast in this modern office.

The 245 remote stations—which look just like ordinary telephones—are connected to a bank of 24 central recorders via the switchboard that was specially designed and built by the Gray Manufacturing Company who also produce the PhonAudograph equipment. The switchboard has a capacity of 400 stations and 40 recorders — for future expansion of the system as needed.

In addition, there are 22 secretarial machines in the transcription center. When a disc on a recorder is completed, it is placed on one of these playback machines to be typed by a girl in the center.

The recording machines, and the typists, are divided into four general classifications, according to the type of language or terminology used: (1) engineering, (2) accounting, (3) general services, and (4) marketing and sales. In this way the typists become accustomed to the terms used in the dictation, and greater speed and accuracy is achieved.

The pneumatic tube system, the first of its kind in the United States, has 20 stations and a dial system. When an executive has finished dictating a letter, he can put the accompanying file in a container, slip it into the tube, and dial the proper destination. In that way the girl in the transcription center has the complete file with her when she types the letter. The system was produced by the International Standard Trading Corporation, a German affiliate of International Telephone and Telegraph.

In addition to the main telephone dictation system, there are several other special pieces of dictating equipment. For instance, four inter-office telephones are connected to four recorders for the handling of code and cable work.

Also there are two "satellite" installations for confidential work in which one station is connected to one recorder exclusively. These are for dictation having to do with employee relations and with annuity and insurance programs. ★ ★ ★

Ten Commandments for Longevity

Everybody can make their lives begin at 40, and have just as much fun as they had in their teens — with the advantage of added wisdom and maturity by following 10 simple "commandments"

Dr. E. J. Murphy

1. **Resolve not to grow old.** Youth is indeed a state of mind — age is often an unnecessary surrender. Live in the present and the future. Forget "the good old days," for those who live in the past grow old accordingly. Watch the tendency to say, "I remember when" and retain an elastic mind. Keep an interest in events happening now — and in future developments. Keeping young is a personality trait that makes one resolved never to admit to being old. "Act your age" in the treatment of your body — but think and dress up-to-date. Do not banish yourself from the company of those younger than yourself.

2. **Slow down.** You may be able to go as fast as ever but this invites ageing. Make haste slowly for a longer, more useful life.

3. **Avoid fatigue — it kills.** When tired, rest promptly and completely. Fatigue produces poisons which hasten old age. Don't drive yourself to exhaustion.

4. **Learn to relax.** Even when working keep the muscles loose to save wear and tear on the nervous system. Try to lie down for a half hour each day.

5. **Control your emotions.** Don't whip your nerves with "scenes." They sap energy, slow you down, lower efficiency — a needless "dither" is destructive.

6. **Cultivate patience.** Adopt an unruffled attitude towards life. Be calm, learn to wait, adopt a moderate "nothing matters" philosophy. Impatience is a deterrent to good health.

7. **Develop a hobby.** Start, and maintain an interest in something entirely different from your normal work. Play, read current books, take photos. Collect and cultivate a "do it yourself" habit.

8. **Practice moderation.** The "good things of life" can be very bad if excessive indulgence is habitual. Too much of anything is worse than nothing at all. Excess dulls the appetite, and robs you of keen judgment, which belongs to youth. Excess produces the boredom of age.

9. **Watch for danger signals.** There are no "normal" diseases of old age — there are conditions, however, that result from bad living habits and which happen more easily than others. Chronic indigestion, insomnia, headache, and fatigue are common. They are symptoms to warn you of sickness. Seek professional help immediately.

10. **Watch your waistline.** An accumulation of fat after 40 is a danger to the heart, kidneys, and liver. Carrying too much weight is exhausting. The young can endure this — after 40 such obesity is a dangerous handicap.

Dr. Murphy is with National Chiropractic Association, Washington, D. C.

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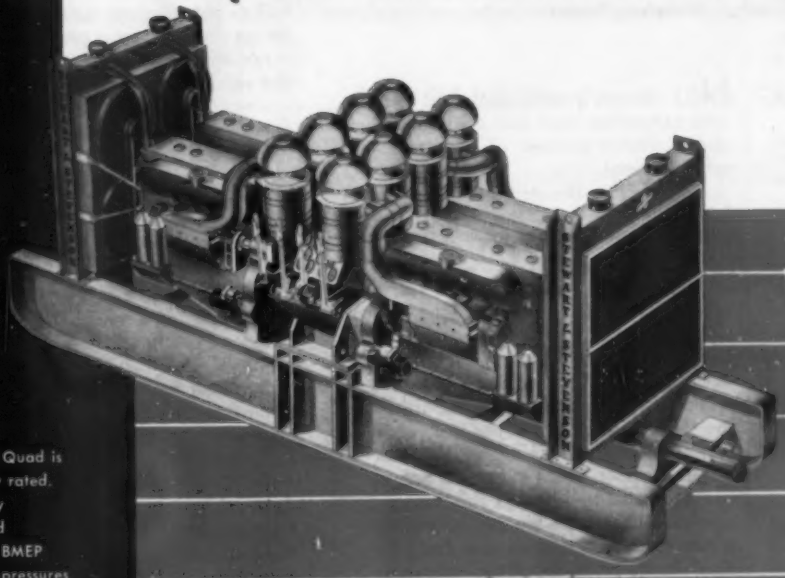

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- Adapted, developed and guaranteed by Stewart & Stevenson, The Nation's Largest Distributor of Diesel Engines.

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Several years ago, Stewart & Stevenson introduced the Series 6-71 Quad to the oil industry. No other engine unit has ever matched it for service. Now, here is a new, higher horsepower 6-110 Quad with the same characteristics for dependability and performance of the earlier model, *yet with 55% more horsepower.*

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Memo for Your Secretary

JOHN RASCO

This memo will balance "How to Treat the Old Girl" (*The Petroleum Engineer*, September, 1956, Page E-24). Your secretary probably called your attention to that one; now you can put this on her desk. It is reprinted from *Texas Industry*, September, 1956, where it was carried in "Ideas at Work" column. Mr. Rasco is director of public relations for Texas Manufacturers' Association, Houston, Texas.

NOT only do quite a number of business executives read this column, but also a sizable number of their secretaries it seems.

Last May we devoted this space to a brief discussion which might have been called "Care and Feeding of Secretaries." It was frankly intended to call attention to the value of a good secretary and give the bosses some tips.

Reaction came from both secretaries and bosses. More than one TMA member has reported his secretary used that column to rate him, and admonished me for laying him open to such scrutiny without warning. So it is with a selfish reason that I must take pen in hand to turn the tables. From various unidentified sources we have compiled a few tips to secretaries and feel that they should be passed along in fairness to those of us who fared none too well in our secretaries' ratings.

The secretary who scores high on this check-list will find it's fun to work, and that life is simpler and more rewarding.

★ DON'T:

. . . Call the boss by his first name or his last name without "Mr." regardless of the informality of the office, if outsiders are within hearing distance.

. . . Giggle, wring hands, or develop other nervous mannerisms.

. . . Correct him in front of others. When you catch a mistake, tell him about it courteously and in private. Of course, many mistakes can be corrected without mention.

. . . Slip out of the office, arrive late or return late without his knowledge and approval.

. . . Use your desk for a vanity. Personal grooming should be done at home on your own time. Make-up repairs should be done in the powder room.

. . . Make excuses or alibis. Work with as few errors as possible and take whatever corrections are necessary cheerfully and patiently.

. . . Speak out of turn or listen to the office grapevine. If you want to know something, ask your boss, not the girl in the office three doors down. And remember, there are some things which are of no concern to you. Don't pry.

. . . Fail to give the boss an occasional pat on the back for a good job. He needs recognition just as you do and values your opinion more than you might imagine.

. . . Forget the responsibility for your office's work rests primarily with the boss. So does the credit.

. . . Write personal letters on company time.

★ DO:

. . . Respect your boss as a person and for his ability. Remember, he had to have many qualifications to become your boss.

. . . Be yourself without pretenses and show everyone common courtesies.

. . . Organize your work efficiently and get it done on time. If a lull should come up, root around for things to do. Nothing is more noticeable than someone who is always doing something, unless it is someone with obvious time on her hands.

. . . Keep your personal problems to yourself, even though the boss may give you a complete run-down on his.

. . . Jealously guard his confidences. It's a tribute you should appreciate. Blabbing them starts you on the road to becoming a typist.

. . . Be sure you've earned it before asking for a raise, and give him ample time to grant you one voluntarily.

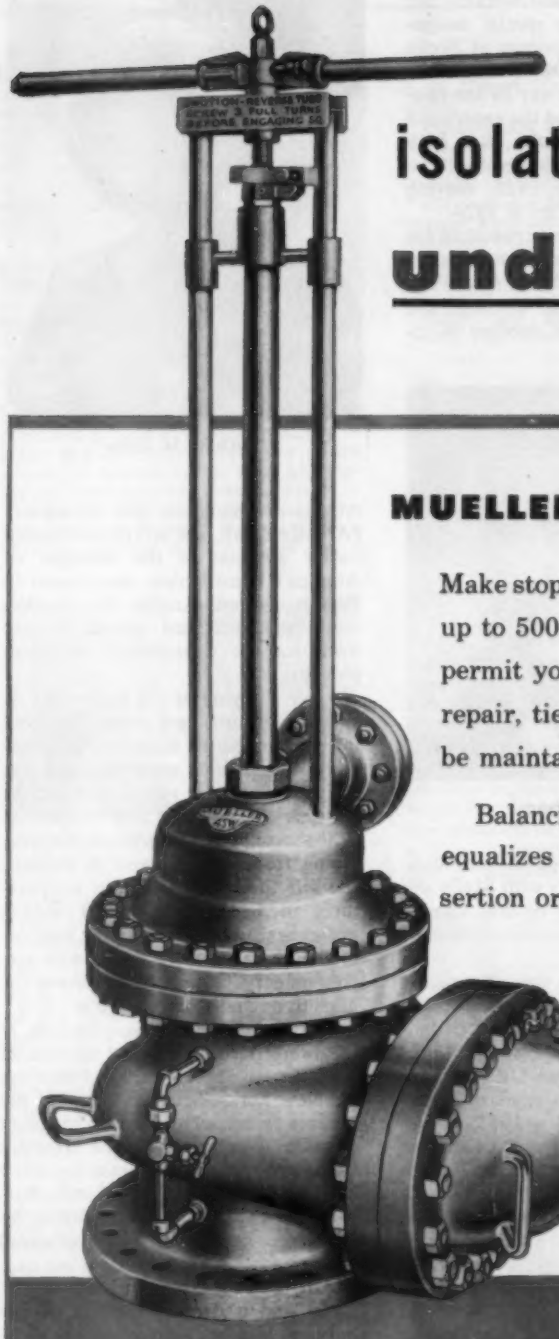
. . . Help fellow-workers when it is needed. You may need them later.

. . . Keep dictionary and secretary's handbook within easy reach and use them.

. . . Proof-read all work before allowing it to leave the office. A boss who later discovers mistakes in letters he signed but didn't read is not going to be easy to work for that day. It is a measure of trust if he signs without reading, so merit it.

. . . Work overtime cheerfully when press of business makes it necessary.

★ ★ ★



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Make stop-offs on 10" and 12" lines under pressures up to 500 p.s.i. Mueller No. 4 Line Stopper Units permit you to isolate a complete line section for repair, tie-in or relocation. If desired, flow may be maintained, through an independent by-pass.

Balancing pressure valve in completion plug equalizes pressure in fitting, permitting easy insertion or removal of plug.

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MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS

Professional Engineer

Graduating with a degree in geology was **Martha Gallagher's** entree to the petroleum industry. As a geologist with the Bankline Oil Company, Los Angeles, California, her duties are varied, and according to Martha, always interesting.

Since her family, headed by a refinery engineer, has always lived in oil communities, it was only natural for Martha to follow the pattern. At the University of California at Los Angeles she majored in geology, simultaneously

Martha Gallagher

working part time in the university's paleontology laboratory and the city's public library. Both jobs, according to Martha, provided valuable experience on her present position. Immediately after graduation Miss Gallagher joined Bankline. Knowledge gained from this eight-year job has enabled her to register under California law as a professional petroleum engineer.

Active in the Los Angeles Desk and Derrick, she also belongs to the American Association of Petroleum Geologists and edits the association's monthly newsletter for the Pacific Section. Hiking, camping, and mountain vacations are favorite activities. Music is another hobby. She plays both piano and violin, and plays violin in the Brentwood Community Symphony Orchestra.

Unit Supervisor

Starting as part-time bookkeeper of a small electric shop and working her away up to handling special assignments for the vice president of Skelly Oil Company, **Eva J. Dunham** built her success story the hard way by the contemplation of issues and the experience in solving them. Shortly after high school graduation Eva joined Skelly in Eldorado, Kansas, in 1922, moving with them to Kansas City in 1924.

As secretary to the vice president for 10 years, Eva analyzed financial statements, originated methods, forms and records on forecasts of earnings and expenses, and handled product distri-

Eva Dunham

bution of tenders to pipe line terminals. During her early years with Skelly she attended night school of law, finance and accounting, an extension course of Kansas University.

Her next move up was unit supervisor on special assignments for the vice president. These varied assignments included originating control procedures and records on OPA fuel oil and gasoline coupons, analyzing government contracts, and in 1955, serving as head of women's activities for the Missouri Natural Gas and Oil Resources Committee of API.

Active in outside organizations, she is a member of Women's Chamber of Commerce, Soroptimist International, Kansas City Safety Council, Business & Professional Women's Club, and Desk and Derrick Club. Eva's hobby is bridge, but doesn't let it keep her from a baseball game. She considers her friends to be her most valuable possession.

Administrative Assistant

Administrative and technical ability combined into an adventurous career in the oil industry for **Barbara St. John.** One of the highest ranking women on

Barbara St. John

Arabian American Oil Company (Aramco) staff, she serves as administrative assistant to the manager of Aramco's construction department in Dhahran, Saudi Arabia. She handles most personnel and administrative work for the department's 415 employees.

After studying at the University of Washington for two years, in 1942 Barbara joined the Standard Oil Company of California, and a year later was assigned as senior yields clerk on the wartime Canol pipe line project in Whitehorse, Yukon Territory, Canada. Going from one extreme to another, she left the subzero Yukon temperatures in 1944, following a second assignment to Dhahran, as the first secretary given overseas duty on Aramco's refinery project. While there she filled in on many different jobs.

During her second two-year stint at Dhahran, Barbara attained the title of administrative specialist. Next stop was the New York office, when in 1951 she became personnel assistant to the chief engineer. When the Aramco Overseas Company opened an engineering office in The Hague, The Netherlands, Barbara spent six months there setting up administrative, filing and personnel systems.

An unquenchable enthusiasm for travel and a deep interest in people have led Miss St. John to use her vacations to the fullest with trips to many out-of-the-way corners of the globe. Twice she has covered Africa by car and local conveyances such as boats and ox carts. No stranger to any part of Western Europe or the Middle East, she has also circled the globe. History, geography and photography are her favorite hobbies and she has gathered a large collection of books and colored slides from her travels.

PERSONALS

B. Brewster Jennings, board chairman of Socony Mobil Oil Company, has been named chairman of a Petroleum Tanker Requirements Committee of the National Petroleum Council. The study will cover world-wide tanker construction plans to 1965 and means for increasing both their number and capacities.

F. Cushing Smith has been named general manager of the supply and transportation department of Standard Oil Company (Indiana). He will direct and co-ordinate the distribution economics, operations, purchasing, and traffic departments.

Smith will fill the vacancy created recently when **Dr. Robert C. Gunness** was promoted to executive vice president to direct and co-ordinate operations of the company's manufacturing, sales, and supply and transportation departments.

Smith is a graduate of Cornell University and joined Standard Oil in 1943 as a chemical engineer at Whiting, Indiana.

C. W. Nave

R. M. Sebastian

C. W. Nave, general manager of the Atlantic Refining Company of Brazil, has retired and is succeeded by **R. M. Sebastian** who has been serving as assistant general manager. Nave began his career with Atlantic in 1921 and in 1927 was appointed general manager and elected to the board of directors of the Atlantic Refining Company of Brazil.

Sebastian joined Atlantic's legal department in 1944. He is a graduate of the Law School of the University of Pennsylvania.

At the thirty-sixth annual meeting of the American Petroleum Institute, thirty-four oil men were honored as having excelled in their particular phase of the oil and gas industry. They are as follows, by division:

Division of Production: **W. F. Herbert,** The Texas Company; **S. S. Parker,** National Tank Company; **E. P. Hayes,** California Texas Oil Company, Ltd.; **J. C. Slonneger,** Continental Supply; **W. O. Clinedinst,** National Tube; **W. V. Vietti.** The Texas Company; **John Woodruff,** Texas University; and **C. E. Beecher,** Cities Service.

Division of Transportation: **W. B. Jupp,** Socony Mobil; **R. D. Wyckoff,** Gulf Research; **R. J. Whitley,** Socony Mobil; **J. L. Shoemaker,** Service Pipe Line, **C. S. Jones,** Richfield Oil; **G. H. Hill, Jr.,** Cities Service; **P. J. Bond,** Pure Oil Company; **M. G. Gamble,** Esso Shipping Company; **R. J. Walshe,** The Texas Company; and **R. R. Clagett** (deceased) Pure Transportation.

Fundamental Research: **G. M. Knebel,** Standard Oil (New Jersey); **W. G. Lovell,** Ethyl Corporation; and **R. E. Wilson,** Standard Oil (Indiana).

Oil Industry Information Committee: **Conger Reynolds** (retired) Standard Oil (Indiana), **D. R. McCallum,** Sinclair Refining; **R. B. Glass,** Socony Mobil; **A. J. De Blois,** De Blois Oil; and **R. A. Douglass,** Ethyl Corporation.

Safety and Fire Protection: **C. D. Norris,** The Texas Company.

Division of Marketing: **J. G. Jordan,** Shell Oil Company; **F. R. Markley,** Sun Oil Company; and **D. T. Colley,** Atlantic Refining.

Finance and Accounting: **P. C. Salman,** Socony Mobil.

Crude-Oil Measurements: **O. D. Stallard, Jr.,** Magnolia Pipe Line.

A. P. I. C.: **David Proctor,** Gulf Oil Corporation.

Petroleum Reserves: **Morgan J. Davis,** Humble Oil.

S. K. McCauley has been appointed manger of the Iran Atlantic Company. In this new position he will be directly responsible for Iran Atlantic operations.

Following his graduation from the Massachusetts Institute of Technology, McCauley joined Atlantic in 1941 as a chemical engineer in the research and development department. He attended the Massachusetts Institute of Technology on a Sloan Fellowship, receiving a MS degree in industrial management in 1950.

Edd R. Turner, president of Pan American Production Company, Houston, Texas, has retired. He has been in the oil industry for 41 years, starting with The Texas Company in 1915 and in 1929 he served as assistant to the production vice president of Continental Oil Company. In 1935 he joined Pan American. Turner is a board member of the general Mid-Continent Oil and Gas Association.

E. R. Turner

M. E. Smith

Maurice E. Smith has been named vice president, finance, a new position in the Husky Oil Company, Cody, Wyoming. He began his career with Husky in 1950 as an executive secretary.

Smith graduated from Denver University in 1942 with a degree, and in 1948 received his LLB from Stanford University Law School.

John L. Porter, technical advisor to the Empresa Nacional del Petroleo of Chile since 1948, is returning to California in January.

Roy C. Hackley, Jr., patent attorney, has been appointed to the newly created position of patent counsel for Continental Oil Company, with headquarters in Ponca City, Oklahoma. He has been a director and vice president of Houdry Process Corporation, a special assistant to the U. S. Attorney General, and held various positions in the Department of Justice. He received his law degree in 1931 from the University of California.

W. G. Moriarty of Dallas, Texas, (seated) assistant general superintendent of Magnolia Petroleum Company, explains allowable tables to **Dr. Josef Klaus,** (left) governor of the state of Salzburg, Austria, and to **Dr. Heinrich Gleissner,** governor of the state of Upper Austria. In background are **Joseph L. Stevens,** U. S. State Department escort and interpreter, and **Nicolas Lanyi,** Magnolia petroleum engineer. The Austrian governors were in Kilgore, Texas, October 19, 1956, to view the giant East Texas oil field during their U. S. tour.

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Imagine . . . a slurry pump which permits the proportion of slurries in the mix tank to remain constant . . . with pumping rates variable from max mum to ⅓ of maximum. Manzel *guarantees* such performance with its new SP-90 Slurry Pump. Field engineers are ready to consult with you.

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Personals

W. M. Parks

W. B. Kirk

Ron Stever

▸ **William M. Parks,** vice president and general counsel, and **Wilford B. Kirk** have been elected to the board of directors of Nortex Oil and Gas Corporation, Dallas, Texas. **Ron Stever** has been elected to serve in place of **Arnold H. Bruner** who has resigned.

Kirk is vice president of Texas Bank & Trust Company of Dallas, Texas. He is a graduate of the University of Notre Dame, and attended Harvard School of Business Administration.

Stever is president of Ron Stever & Company, consulting firm of Los Angeles, California.

▸ **C. D. Everhart** has been appointed Atlantic Coast regional director for the Oil Industry Information Committee of the American Petroleum Institute. He will succeed **E. E. Robinson** who has resigned.

DEATHS

▸ **Gaile E. Lindley,** 55, Standard Oil Company of California executive, died at his home in New Jersey, following a heart attack. Lindley was president of the California Transport Corporation and California Tanker Company, both Standard subsidiaries.

▸ **Albert S. McKenzie,** 59, died in October of a heart attack. He was assistant vice president of sales for Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company, and affiliated companies.

He celebrated his twenty-fifth year with the company in July.

▸ **William S. Mackey,** 67, an independent oil producer in Houston, Texas, has passed away following a heart attack.

▸ **Julio G. Bejarano,** 54, manager of Shell Chemical Corporation's Denver plant, died in October after a brief illness. He joined Shell in 1926 as a designer in the engineering department and moved from California to Denver, Colorado, to manage that plant when Shell Chemical purchased it in 1952.

▸ **William "Bill" Heaton Rinehart,** 68, died in October following a stroke which had incapacitated him since summer. He was with Iraq Petroleum Company, Ltd., where he joined as toolpusher in Syria in 1938. He had spent forty years in the oil well drilling business.

LAUGH with BARNEY

Money is something that things run into and people run out of.

A very large woman entered a bus and two men got up and gave their seats. She was so big that a small boy sat gazing at her in wonder.

Eventually she said impatiently, "Little boy, what are you looking at me for?"

The youngster, embarrassed, stammered: "L-l-lady, there isn't anywhere else to look."

Barney: "Psychologists say a hysterical girl is most efficiently quieted by a firm kiss."

Billy: "And do they say how to get them hysterical?"

A Harvard scientist has just disproven the old story about the birds and the bees. He put a bird and a bee together — and nothing happened.

She was out all night and got a little rent in her stocking.

A young bride of three months complained to her relatives about her husband's continued drinking habits.

"If you knew he drank, why did you marry him?" she was asked.

"I didn't know he drank until one night he came home sober."

A truck driver pulled up alongside one of those tiny foreign sports cars, stalled on the highway, and poked his head out.

"What's the trouble, pal?" he grinned. "Need a new flint?"

Mildred: "Which do you think is more important to a girl, beauty or brains?"

Lillian: "Well, let's put it this way . . . most men can see better than they can think."

One of Governor Williams' aides in Lansing had to suppress quickly a directive given out by a state official.

Posted on the bulletin board in his office were these inviting words:

"Executives who have no secretaries of their own may take advantage of the girls in the stenographic pool."

"Your eyes," thrilled the ardent swain. "They're beautiful. I see dew in them."

"Take it easy, bub," drawled his girl. "That ain't dew. That's don't."

A man browsing in a pet shop was approached by an attractive young girl who asked if she could assist in his selection.

"Well," the prospective customer replied, "I have been thinking of getting a pet for a client of mine. He is a semi-invalid; can't get out of the house. Man about 60; very wealthy; nice sort of chap. He has no relatives — so the idea of a pet came to me."

The girl considered, and then brightening visibly, said, "I think I have just the thing!"

"Good," said the man. "What kind of a pet do you suggest?"

Replied the bright young lady: "Me!"

A neurotic builds air castles. A psychotic lives in them. A psychoanalyst collects the rent.

There is nothing like a good auto accident to make you forget your other troubles.

A Scotsman was leaving on a business trip and called back as he was leaving. "Good-bye all, and dinna forget to take little Donald's glasses off when he isn't looking at anything."

Aggressive wife to meek little husband whom she had just raked over the coals for making a fool of himself at a party:

"And don't be sitting there," she shouted, "making fists at me in your pockets, either!"

Tact is the art of making your company feel at home when you wish they were.

"I know a place where women don't wear anything — except maybe a string of beads once in a while."

'Holy Gee, where?"

"Around their necks, stupid."

Be careful about calling yourself an "expert." One definition is that an "ex" is a has been, and a "spurt" is a drip under pressure.

Now! PRECISION EXPANDING MANDRELS by CHAMPION

The expanding sleeve, mounted on tapered arbor, expands automatically to fit the hole. Inserted by hand — no arbor press needed. Always an exact, positive, concentric fit. Locked by a single mallet blow. Unlocked in the same way. CHAMPION Expanding Mandrels are used in machine shops around the world. Save time, cut production costs, whether the job calls for machining one piece or a thousand.

Precision Model has expansion range of .010". Available in regular sizes to fit holes from ½" to 9½" diam. Holds work to tolerances of .0002" run-out. Guaranteed for precision grinding, turning and milling operations.

Standard Model maintains close tolerances, handles material of any length bore, hard or soft metals — from thin tubes and bushings to heavy castings and forgings. A set of fourteen will fit every hole from ½" to 9½" diameter.

CHAMPION Expanding Mandrels can be made in special shapes and sizes to fit any specifications. Quotations on request. Write for descriptive folder today.

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OIL and GAS TRADE NEWS

Polyethylene Process Acquired

A revolutionary new process utilizing irradiation to modify and improve polyethylene and other polymers has been acquired through an exclusive licensing agreement by W. R. Grace & Co. from the Sequoia Process Corporation of Redwood City, California.

The irradiation process is claimed to give polyethylene remarkable resistance to heat, reduce cold flow and stress cracking, and increase tensile strength.

Oil Tool Machine Shop Opened

Avondale Marine Ways, Inc., New Orleans, Louisiana, announced that an all-new machine shop is now complete and in service at its Harvey plant.

Youngstown Buys Out Emsco

The Youngstown Sheet and Tube Company, principal stockholder of Emsco Manufacturing Company, has purchased all of Emsco's properties, assets and rights and assumed all the obligations and liabilities of the company.

All business conducted by Emsco will be under the name of Emsco Manufacturing Company, a division of The Youngstown Sheet and Tube Company. The Johnston Pump Company Division of Emsco at Pasadena, California, will continue its operations as Johnston Pump Company, a division of Youngstown.

No charge in sales, operating or personnel practices is presently contemplated by Youngstown for either division.

Celanese to Build Polyol Unit

To meet the increasing demand for trimethylolpropane in the rapidly growing polyurethane plastics and coatings field, Celanese Corporation of America has started construction of a new polyol production unit at its Chemical plant in Bishop, Texas.

Unit is expected to be completed and producing by the last quarter of 1957. In addition to providing trimethylolpropane and other intermediates for polyurethane synthesis, this new unit will produce a range of other products that will serve end uses in alkyd resins, high-quality brake fluids, and other expanding industrial fields.

Magcobar Offshore Division

Formation and activation of a Louisiana offshore division of the drilling mud department of Magnet Cove Barium Corporation has been announced.

This division is designed to give a more efficient service to Magcobar customers and is comprised of a group of specialized service engineers.

The Louisiana offshore division is under R. E. "Rags" Hinchliffe and is headquartered at Lafayette, Louisiana.

Houston Tech Labs Opens Plant

Three leaders of the oil industry formally opened the new Houston Technical Laboratories building with a cloud of orange smoke recently at Houston, Texas.

Eugene McDermott, chairman of the board of Texas Instruments Incorporated, parent firm of HTL, and Dr. J. C. Karcher, president of the Concho Petroleum Company, co-founders of the seismic method of oil field exploration, were assisted by Cecil Green, chairman of the board of Geophysical Service, Inc. They activated an HTL blaster to light a smoke fuse that cut a ribbon across the building entrance.

The 40,000 sq ft of floor space has been arranged within the building for flexible use in the expansion of the company. Inside walls are constructed of plate glass and plywood backed by sound-damping material. Departmental partition walls can be easily moved as the need arises.

New Ethyl Plant in California

Ethyl Corporation has announced plans for an antiknock compound manufacturing plant in California.

The new plant will be located in the San Francisco Bay area, and will be large enough to serve the growing needs of the West Coast oil industry for "Ethyl" antiknock compounds.

Kendall Plans New Plant

The Kendall Company has started construction of its new 35,000-sq ft, $1,300,000 plant in Franklin, Kentucky.

This plant will produce Polyken industrial tapes, plastic film, and plastic specialties. The two-story plant will triple the company's capacity for these products, which are now being made in Chicago, Illinois.

Carbide and Carbon Lab Center

A start will be made this fall on a multimillion dollar program for a new development laboratory at South Charleston, West Virginia for Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation.

The ultra-modern facilities, when completed in mid-1958, will bring together a majority of the scientists and engineers now working in many separate buildings of Carbide's development laboratories there.

This new project, on an 18-acre tract, includes a main laboratory building, a high-pressure laboratory building, a plastics pilot scale building, and separate facilities for studies utilizing gamma radiation and radioactive tracers.

New Chemical Company Formed

Dr. Robert A. Cooley, formerly with Olin Mathieson Chemical Corporation, has announced the incorporation of a new company, the Propellex Chemical Corporation in Edwardsville, Illinois.

This new company will conduct research and development on and manufacture of propellants and explosives. Major emphasis for the petroleum and mining field will be placed on gas generating devices such as oil well perforators, cement extruders, bridging plugs, and non-electric powered safety devices.

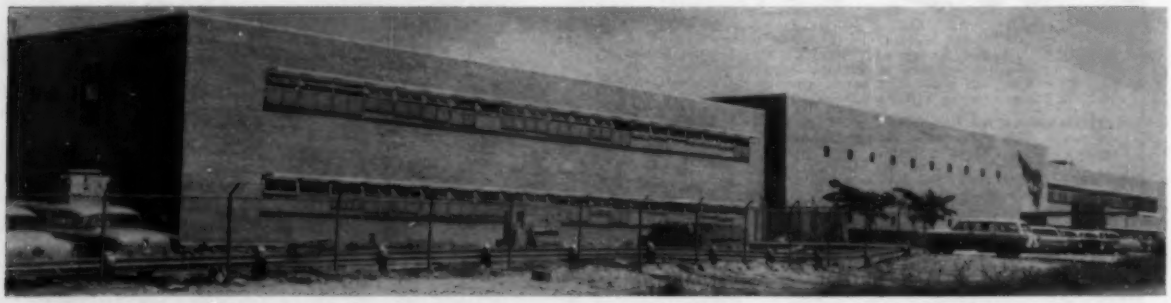
Chemico to Expand Operations

Chemical Construction Corporation has announced plans to expand its engineering design and construction services. The company will undertake projects in both the chemical and petrochemical processing industries.

Cummins Engine Sets Up Firm

The sale of certain assets of Cummins Diesel Sales Corporation, Charleston, West Virginia, to a new company, Cummins Engines of West Virginia, Inc., has been announced by Cummins Engine Company, Inc.

President of the new corporation is L. E. Williams, who until this purchase has been manager of distribution, Cummins Engine Company, Inc. Headquarters for Cummins Engines of West Virginia will remain at Charleston.



Halliburton Building Completed. Several major building projects have been completed by Halliburton Oil Well Cementing Company, including a new 18,000-ft wing at the company's Technical Center; a four story addition to the administration building at plant 1 and a new building at plant 2. With the completion of the Technical Center addition (above) more than 50 engineers, chemists and technicians will be added to the research group.

New 32,000-ton Oil Tanker is the first of a new series of 32,000-dw ton oil tankers for The British Petroleum Company's shipping organization, BP Tanker Company. Tanker was launched and named "British Industry" by Lady Kirkpatrick, wife of Sir Ivone Kirkpatrick, Permanent Under-Secretary of State in Britain's Foreign Office, at John Brown & Company's yard at Clydebank, Scotland.

New Supply Company Formed

Formation of a new oil field equipment company to be known as the Crescent Oil Well Supply Company has been announced.

A. Rex Watkinson Jr. will be president and general manager of the company. The organization will have main offices in Tulsa, Oklahoma, and a sales outlet in Okemah, Oklahoma.

George Coleman Jr. has been appointed store manager and sales representative for the Okemah store.

Monsanto Divides Sales Sections

Separate sales sections for agricultural chemicals and for industrial chemicals have been organized within the sales department of Monsanto Chemical Company's inorganic chemicals division.

In the industrial chemicals sales section, W. R. Corey has been appointed director of industrial field sales and J. B. Trotter will remain as director of industrial product sales. A newly organized section, headed by Dr. P. G. Arvan as director of industrial technical service, will provide strengthened technical service for the industrial products.

Honeywell Plans Suburban Plant

A new three-acre manufacturing plant and home office for Minneapolis-Honeywell Regulator Company's valve division will be constructed at Fort Washington, Pennsylvania.

The 120,000-sq ft building, representing an investment of more than $1,500,000, will house on a 25-acre site, the entire manufacturing, sales, research, development, and administrative facilities of the division, now located in Philadelphia, Pennsylvania. Construction of the plant will take approximately eight months to finish, with production scheduled to commence next summer.

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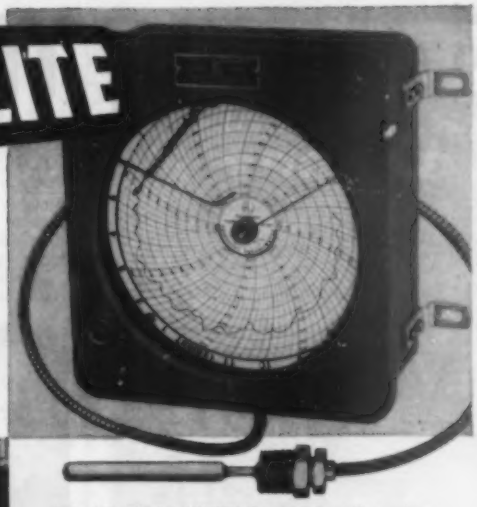

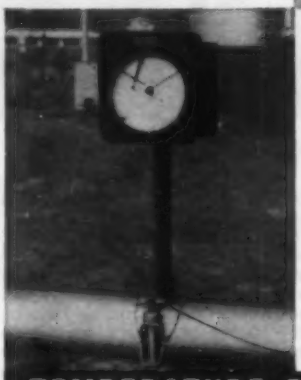

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"ATLAS" CHROME CLAD
OIL GAGING TAPE

Atlas lines are 50% heavier than standard weight steel tapes. Full 20-ounce solid brass plumb bob penetrates heavy oils. Easy to read. Bold black markings contrast with exclusive "glare-free" Chrome Clad surface — oil level shows clearly. Multiple platings prevent rust and corrosion. Wipes clean. Lines are replaceable. Lengths from 18 to 100 feet.

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AS AN ENGINEER

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TRADE PERSONALS

H. N. Mallon has been named to the newly created position of chairman of the board of Dresser Industries, Inc., and will remain as chief executive officer. **J. B. O'Connor,** formerly executive vice president, succeeds Mallon as president.

Gordon G. Guiberson has been elected to Dresser's board of directors. The new

H. N. Mallon

J. B. O'Connor

board member is the president of the Guiberson Corporation, now one of the Dresser Industries.

Hector P. Boncher, operating vice president, will be in charge of Dresser's heavy machinery divisions. Before appointment to his new post, Boncher was general manager of Dresser Manufacturing Division.

Henry Herzig has been appointed operating vice president in charge of Lane-Wells Company, Well Surveys, Inc., and Ideco in the U. S., as well as Security Rock Bits, Ltd., in England. Previously, Herzig was director of manufacturing for Dresser Industries.

Otto Hammer, formerly president of Security Engineering, now becomes operating vice president of Dresser Industries. He will be in charge of the Guiberson Corporation and Security Engineering Company operations.

Robert H. McLemore, formerly director of oilwell services for Dresser, has been made vice president and general manager of the new turbodrill division of Dresser Industries.

Philip L. McLaughlin will head the new petroleum division of Schramm, Inc. Formerly director of drilling research for Cardwell Manufacturing Company, McLaughlin will direct a separate sales and research branch to promote newly designed equipment for air drilling and other oil industry applications.

P. L. McLaughlin

E. F. Shiels

E. F. (Gene) Shiels has been promoted to vice president of Ideco. Prior to his appointment, Shiels was domestic sales manager of Ideco and in his new capacity he will continue to direct the company's sales activities.

W. F. Slater has been elected vice president for sales of Kobe, Inc. He has been general sales manager of the organization.

W. F. Slater

W. A. Griffin

W. A. Griffin has been elected president of Daniel Orifice Fitting Company, having formerly been vice president and general sales manager.

With his appointment, Daniel Orifice Fitting has embarked on an extensive expansion and development program. This program will include an expansion of the Houston, Texas, plant facilities and a transfer of executive offices from Los Angeles, California, to Houston.

Robert M. Greer, who has been serving as first vice president of the George E. Failing Company has been named president and treasurer. **E. L. Alexander,** former vice president of engineering and manufacturing, has been made first vice president.

R. M. Greer

E. L. Alexander

Failing is a subsidiary of Westinghouse Air Brake Company.

C. C. Pryor has been named sales representative for Win-Wall Manufacturing Company. He will represent the company in the Gulf Coast area.

C. C. Pryor

A. F. Canada

A. F. Canada has been elected vice president in charge of sales, centrifugal pumps division of Pacific Pumps, Inc. Canada was formerly centrifugal pumps sales manager.

Trade Personals

▸ **A. I. Thompson** has advanced from sales manager to the position of vice president in charge of sales for Barton Instrument

A. I. Thompson

George Miller

Corporation. **George Miller** has been appointed chief engineer in charge of design and development for the company.

▸ **F. Kenneth Morrison** has been named president and general manager of the Mason-Neilan Division of Worthington Corporation.

He succeeds **Eldon Macleod,** who is retiring after 43 years' service. Morrison was formerly vice president in charge of sales.

Carl W. Gram Jr. has been made vice president in charge of sales. Gram has been manager of the petroleum and chemical sales division.

F. K. Morrison

C. B. Truitt

▸ **C. B. (Ike) Truitt** has been named general sales manager for the Rolo Manufacturing Company. Truitt's more than 20 years' experience in industry have been devoted mainly to work with pressure vessels, controls and metering of crude oil.

W. M. Boren, formerly director of sales and engineering for Rolo, will now devote full time as director of engineering.

▸ **John W. Hendryx** has been promoted from sales engineer to product sales manager for packaged compressors for The J. B. Beaird Company, Inc. **J. E. Kelly,** formerly service engineer, has been named chief service and office engineer.

▸ Fluid Packed Pump Company announces three promotions in its sales department. **Durward Allen** has been appointed district manager of the Abilene, Texas, district, **Vaughn Holton** assistant division manager for the northwest division, and **Verlan Lewis** assistant division manager for the Gulf Coast division.

▸ **Ernest J. Hill** has been named sales manager of Colton Chemical Company, a division of Air Reduction Company, Inc. Hill was formerly assistant sales manager.

▸ **F. E. Pringle** has been appointed assistant general sales manager for The Howe Scale Company. Pringle comes to this newly created position with Howe from Sperry Products, Inc., where he held sales and sales management positions.

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C-2 **X-Ray Answers Knotty Refining Questions** *Vern W. Palen*

C-3 **Chemical Plant Safety** *Elmer Saxon*

C-4 **New Grease for High Temperature Ultra High Speed Operations** *J. Perry Dilworth and James R. Rooch*

PIPELINING

D-1 **A Symposium on Pipeline Flow Efficiency Testing**

D-2 **The Mole . . . What It Is . . . How It Works** *W. F. Krueger*

D-3 **Tapline: A Report on Five Years of Successful Operation**

D-4 **Case History: Outdoor Pumping Equipment** *N. M. Lytle*

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Trade Personals

Fred H. Tinsley has been named export manager for Franks Division, Cabot Shops, Inc. He was promoted from ordnance plant superintendent of Cabot Shops, in Pampa, Texas.

F. H. Tinsley

S. A. Gaylord

Major staff changes in the petroleum sales department of The Goodyear Tire & Rubber Company have been announced.

S. A. Gaylord, former manager of petroleum sales, has been assigned to special projects in conjunction with that department. Appointed to replace Gaylord is **Charles A. Eaves Jr.,** formerly assistant manager of petroleum sales. **J. W. Basista** of the Akron, Ohio, petroleum sales staff assumes the duties vacated by Eaves.

L. W. Short, vice president in charge of sales, Drilling & Service, Inc., has left the United States for Iraq, where he will conduct a special diamond coring program and train local Middle East personnel in operational techniques of diamond coring for this particular type of area.

Short has recently conducted similar programs in South American countries and Canada.

Richard P. Hempel has been named manager of liquid filter sales for Dollinger Corporation. Hempel joins Dollinger after having been an industrial engineer at the Eastman Kodak Company.

William C. Stratton has been named chief engineer of the engineering and construction department of Dravo Corporation. Stratton comes to Dravo from the firm of consulting engineers, Ebasco Services, Inc., New York City, where he held the position of assistant to the manager of engineering.

Dravo also has announced the appointment of **A. A. Nilsen** as manager, ore agglomeration in the engineering and construction department. Nilsen was assistant manager of the American Ore Reclamation Section of Koppers Company, Inc.

Jules M. Arceneaux has been appointed Louisiana division manager by Gammaloy, Ltd., with headquarters in Lafayette. Arceneaux was formerly associated with Eastman Oil Well Survey Company and The National Supply Company in Louisiana.

Charles F. Beran is retiring as a director of Celanese Corporation of America, following 33 years' association with the company. He will be succeeded by **Richard W. KixMiller,** vice president in charge of the Celanese chemical division.

Holley B. Dickinson has been named assistant to the president of Consolidated Electrodynamics Corporation. Dickinson until recently was a vice president, treasurer, and director of Telecomputing Corporation, North Hollywood, California.

W. D. "Ted" Berry, field representative for B & W, Inc., has been transferred from South Texas to Williston, North Dakota, where he will open a B & W, Inc., warehouse.

W. K. Daggett has been appointed sales supervisor for BJ Service, Inc.

He will direct the sales development of new products and services for BJ Service's Texas division, with his headquarters in Odessa. Daggett was formerly associated with Welex Jet Services, Inc., as sales manager and supervisor of sales training.

Milo Harrison Buzzee, industrial designer and research engineer, has joined Tube Turns Plastics, Inc. He will direct the marketing of custom-molded products and handle special assignments.

M. H. Buzzee

D. B. Allison

D. B. (Doug) Allison has been appointed director in charge of the Homco export division of Houston Oil Field Material Company, Inc. Allison retains the position of director in charge of Homco purchasing.

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ENGLAND

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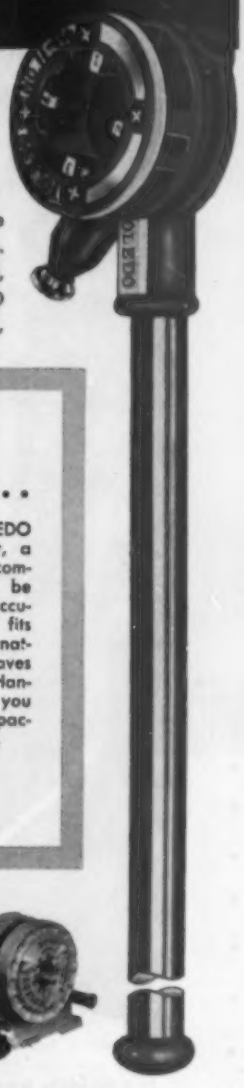

. . . you'll appreciate this popular TOLEDO trio. Pick up the rugged, dependable TOLEDO small Ratchet Pipe Threader. Pull the pawl—drop in a die—you're ready to thread in seconds. You'll like the easier handling, better grip, the famous TOLEDO quality. (⅛ to 2" sizes.) Then,

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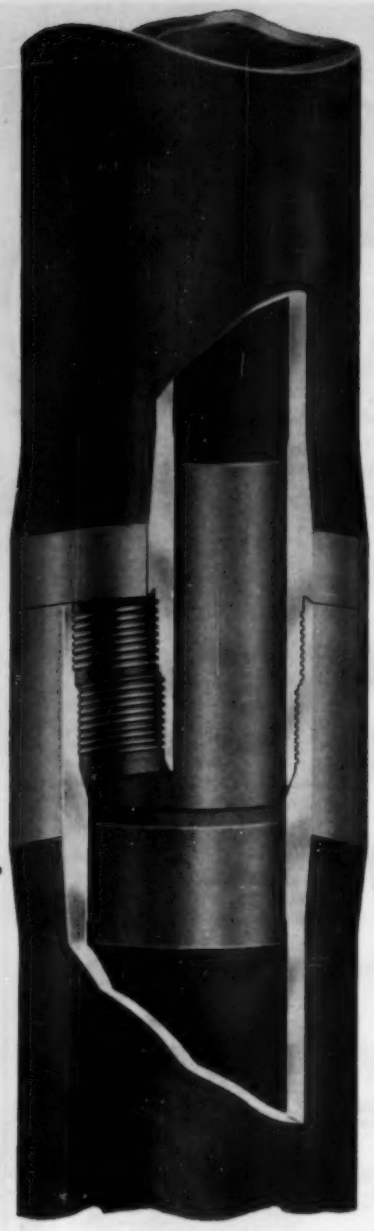

In a Speedtite joint, threads are cut on two diameters. This provides the strongest possible joint cut right into the upset metal. The thread on each step is straight—not tapered—so that its clearance is uniform, allowing for smoother make-up. All Speedtite casing threads of a size are interchangeable, thus eliminating need for cross-over joints.

DEEP DRILLING

demands the best in casing ... and the best available is SPEEDTITE

Yes, Youngstown's Speedtite Oil Well Casing is the modern answer to problems encountered in drilling to greater and greater depths. When field conditions become increasingly difficult, specify Speedtite Casing because it:

- provides the necessary strength and ruggedness to take the increased punishment
- offers faster, safer, more economical setting of long strings
- guards against joint failures
- handles even the most difficult jobs with ease

For satisfactory field performance, Oil Country Tubular Goods must be of the highest quality. Recognizing this fact, Youngstown rigidly quality-controls all steps in its completely integrated operations.

From off-shore drilling sites to the deepest wells in the Southwestern oil fields, Speedtite is busy on the job. Why not let the Youngstown representative show you the many ways Speedtite can increase the efficiency of your operations?

CHECK THESE PRODUCTION ADVANTAGES OF THE *SPEEDTITE* EXTRA-STRENGTH JOINT!

Provides a 100% pressure seal against both internal and external pressures. It's leak-proof up to and beyond the casing's yield point.

Its increased strength over threaded and coupled joints ranges from 30% to 70%. Heavier casing can be run on the bottom of the string and lighter casing on the top—with ample tensile strength in all joints of the string.

A smaller outside diameter provides additional assurance casing will go to bottom. In some fields its smaller OD permits a reduction in hole size—thereby lowering drilling costs.

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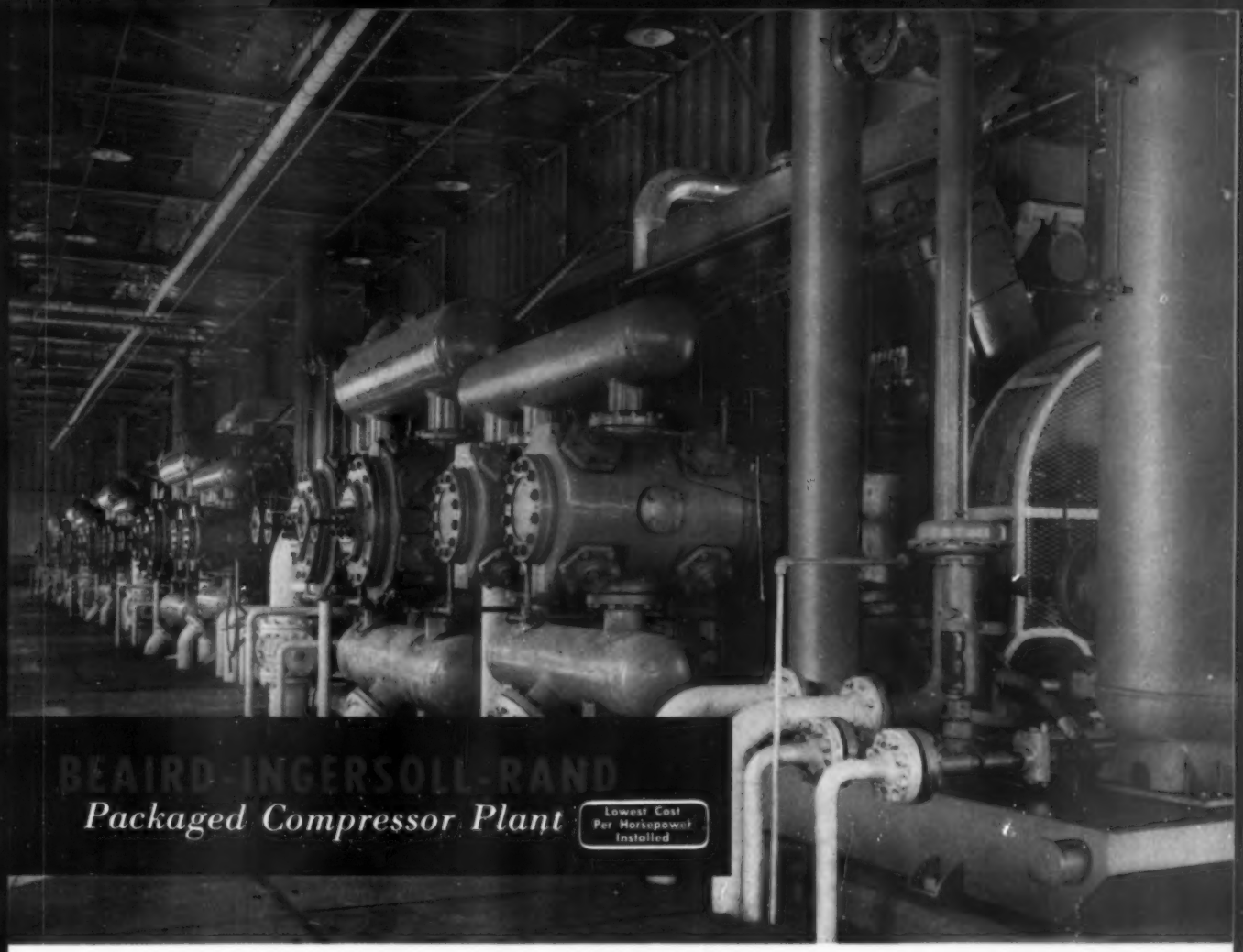

NATURAL GAS PIPELINE COMPANY OF AMERICA'S QUINDUNO STATION—equipped with five Beaird-Ingersoll-Rand 12SVG 660 h.p. packaged compressors. Young radiators with lubricating oil coolers, gas interstage and after coolers and all necessary controls. Other sizes 110 to 660 h.p.

Packaged Compressors Handle —

CRITICAL SOUR GAS PRODUCTION PROBLEM

3300 packaged compressor horsepower is used in the Natural Gas Pipeline Company of America's Quinduno Field station to boost sour casinghead gas through a desulphurization plant and into transmission lines. Providing this horsepower are five Beaird-Ingersoll-Rand 12SVG 660-h.p. units. Gas engineered for the job, the units are equipped with stainless steel compressor piston rods and special rings. Engine radiators which contain gas interstage and aftercooling sections, have been constructed with admiralty metal tubes and aluminum fins. All compressor fittings and scrubber elements have been built from noncorrosive materials.

Capable of handling up to 25 mmcfd, the units pick up at 19 psig and use two stages to boost the gas to transmission line pressure of 260 psig.

Packaged compressors were selected by Natural Gas Pipeline because of the savings that could be achieved in installation time and labor. Also should the gas volume drop off, one or more plants could be moved as complete units to other service. The remaining units would then economically continue production throughout the life of the field. Each of the units when finally taken out of this service, and moved to another, will be almost wholly salvaged.

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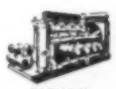
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Capable of handling tanks up to 75,000-gallon capacity, the stress relieving furnace has been installed as part of the tank assembly line. This permits volume production of stress relieved tanks without change or delay in shipping schedules.

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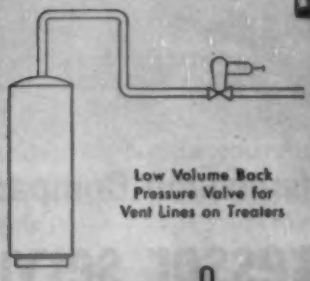
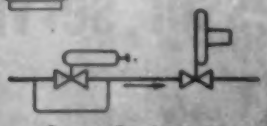
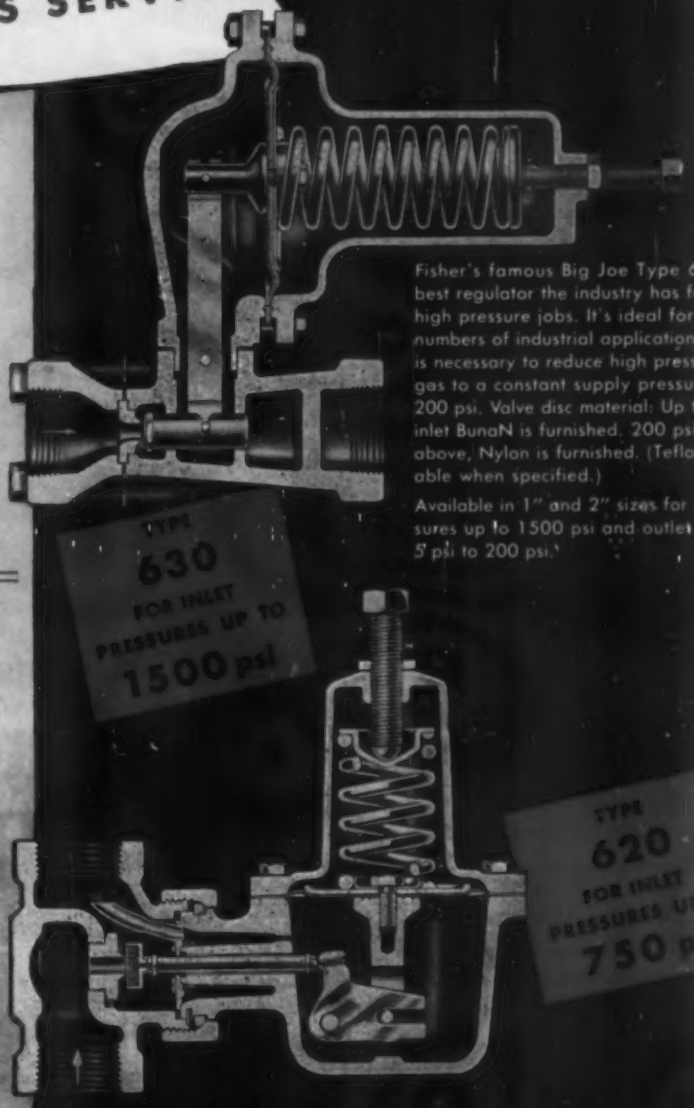

Low Volume Back Pressure Valve for Vent Lines on Treaters


Pressure Regulator For Farm Tap Service

Reducing Valve for Heater Fuel or Treater Furnace Fuel



Fisher's famous Big Joe Type 630 is the best regulator the industry has for rugged high pressure jobs. It's ideal for countless numbers of industrial applications where it is necessary to reduce high pressure air or gas to a constant supply pressure of 5 to 200 psi. Valve disc material: Up to 200 psi inlet BunaN is furnished. 200 psi inlet and above, Nylon is furnished. (Teflon is available when specified.)

Available in 1" and 2" sizes for inlet pressures up to 1500 psi and outlet pressures 5 psi to 200 psi.

For real economy the Fisher Type 620 pounds to pounds regulator is used on same applications as 630 "Big Joe" where pressure and flow requirements do not exceed 750 psi and reduced pressure not above 100 psi.

For inlet pressures up to 750 psi with malleable iron or cast steel body, up to 150 psi with cast iron body. Outlet pressure ranges: Type 620—3 to 60 lbs. (4 springs). Type 621—3 to 100 lbs. (5 springs). Valve disc material: BunaN when inlet pressure is 300 psi or less, and Nylon when inlet pressure exceeds 300 psi.

Sizes: ¾", 1" and 1¼" with cast iron or cast steel body. ¾" and 1" with malleable iron body.

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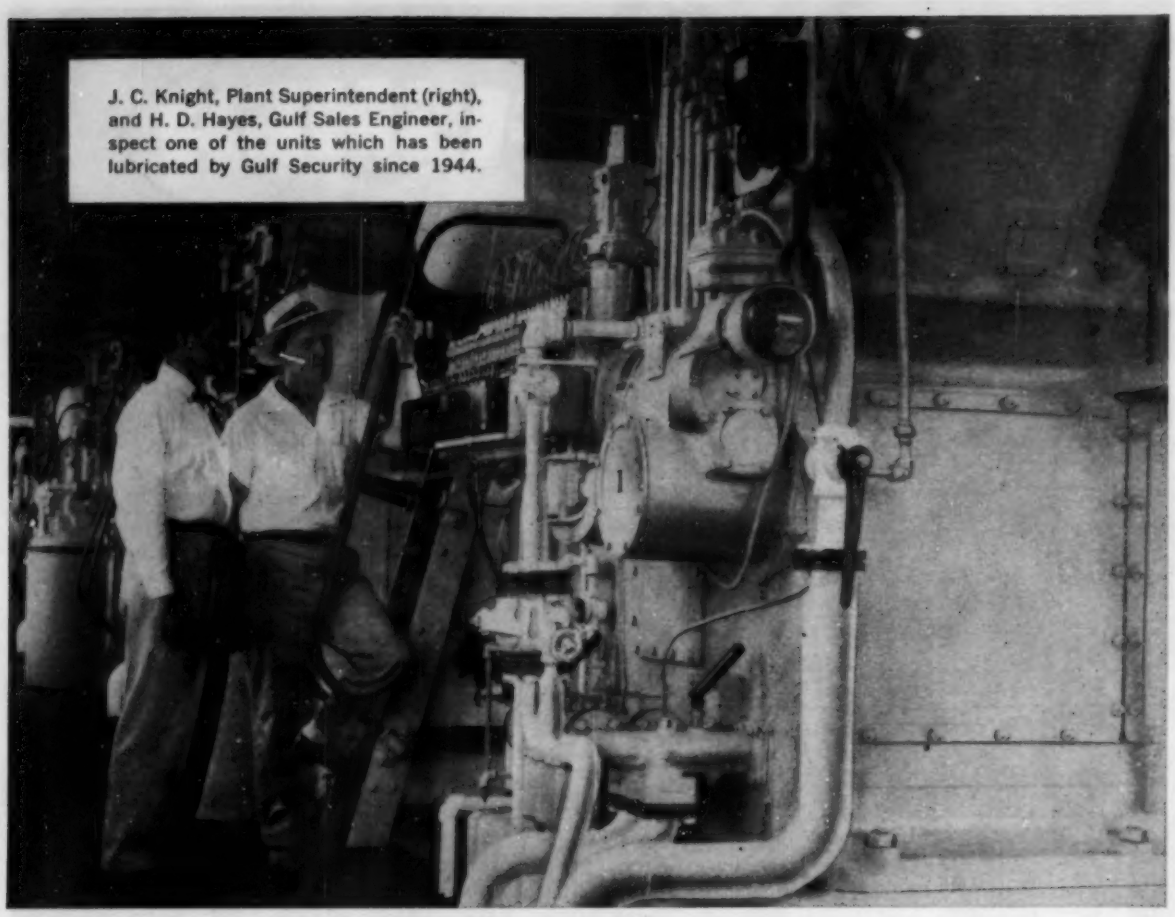

J. C. Knight, Plant Superintendent (right), and H. D. Hayes, Gulf Sales Engineer, inspect one of the units which has been lubricated by Gulf Security since 1944.

At Lobelville Station of Tennessee Gas Transmission Company

12 years of dependable compressor service with GULF SECURITY

With engines totalling 37,500 hp, the Lobelville, Tennesee, station of Tennessee Gas Transmission Company is one of the largest compressor stations in the United States. This station has been lubricated by Gulf Security for the past 12 years.

Gulf Security is a non-additive oil that protects compressor and power assembly cylinders and piston rings against harmful deposits and excessive wear. Like Tennessee Gas Transmission Company's Lobelville station, scores of other transmission plants all over the country are using Gulf Security to prevent operating troubles and keep maintenance costs down.

The Gulf complete "package" includes not only the finest petroleum products and prompt delivery, but also the services of an experienced petroleum engineer to help you with *any* problem that involves a petroleum product. Why not find out if Gulf can be of service to *you?* Your Gulf representative is as near as your telephone.

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THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

exhaustive tests prove:

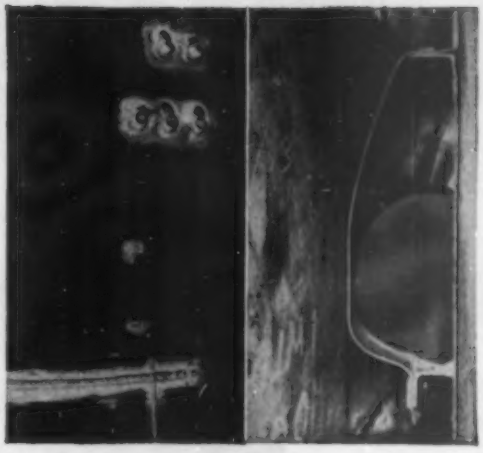
36 YEARS FROM TODAY

TUBESEALS* NOW IN FLOATING ROOF TANKS WILL OPERATE AS EFFICIENTLY AS THEY DO TODAY!

WE DOUBT this can be claimed for any other floating roof seal!

To determine the efficient life-expectancy of the Hammond Tubeseal in service, tests were made under the worst possible conditions to which a floating roof seal can be subjected. The Tubeseal was moved across very rough rivet heads, erection burrs and abrasive weld surfaces, for a total travel of 70,000 feet. This is equivalent to a normal wear of *more than 36 years in actual service.* Moreover, as the tests were run dry, there was the added disadvantage of the absence of lubricating effect normally created by wetted surfaces. Upon completion of these rigorous tests, the scuff band had only worn through the ribs and had barely penetrated through the material, leaving two-thirds of the stock intact; proof that the Tubeseal is unimpaired after traveling 70,000 feet.

The 36 year life-expectancy of a Hammond Tubeseal assumes no mechanical accident and is arrived at in the following manner: Each year a floating roof, in normal service, makes about 48 trips to and from top and bottom of tank. The roof of a 40 foot tank, therefore, will travel 1920 feet per year. Assuming 1920 feet of travel per year (based upon full depth of travel) and applying our accelerated wear test, the Tubeseal will be serviceable for at least 36 years 5½ months.



THE TUBESEAL TEST:

total travel	70,000 feet
travel over vertical weld	46,400 feet (on same line)
Horizontal welded seam crossed	21,200 times
Flat head rivets crossed	63,600 times

CONDITION OF TUBESEAL AFTER TEST: Scuff band had worn through ribs and had barely penetrated into the main material, leaving ⅔ of stock intact.

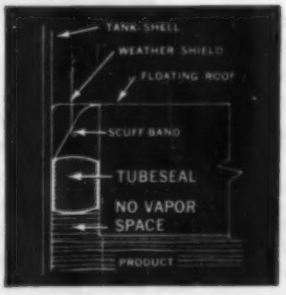
Tests were conducted dry with no aid of lubricant normally resulting from stored product.

Photos show projections used for test. Included are 16"of ⅜" horizontal weld—24" of sharp, irregular vertical weld—2 erection burrs—3 ¾" flat head rivets and 2 ¾" cone head rivets.

THE HAMMOND TUBESEAL
is the most efficient and positive seal known.

it features:

no moving parts
no mechanical maintenance
climate proof
non-corrodible
can operate to bottom of tank or above the top
no vapor space below the seal
entire circumference has tight seal under pressure at all times
longer working life expectancy



NO ROOM FOR VAPORS
NO EVAPORATION
NO CORROSION

**patented* *Write for bulletin TS*

HAMMOND TUBESEAL — THE MOST EFFICIENT AND POSITIVE SEAL KNOWN

HAMMOND IRON WORKS

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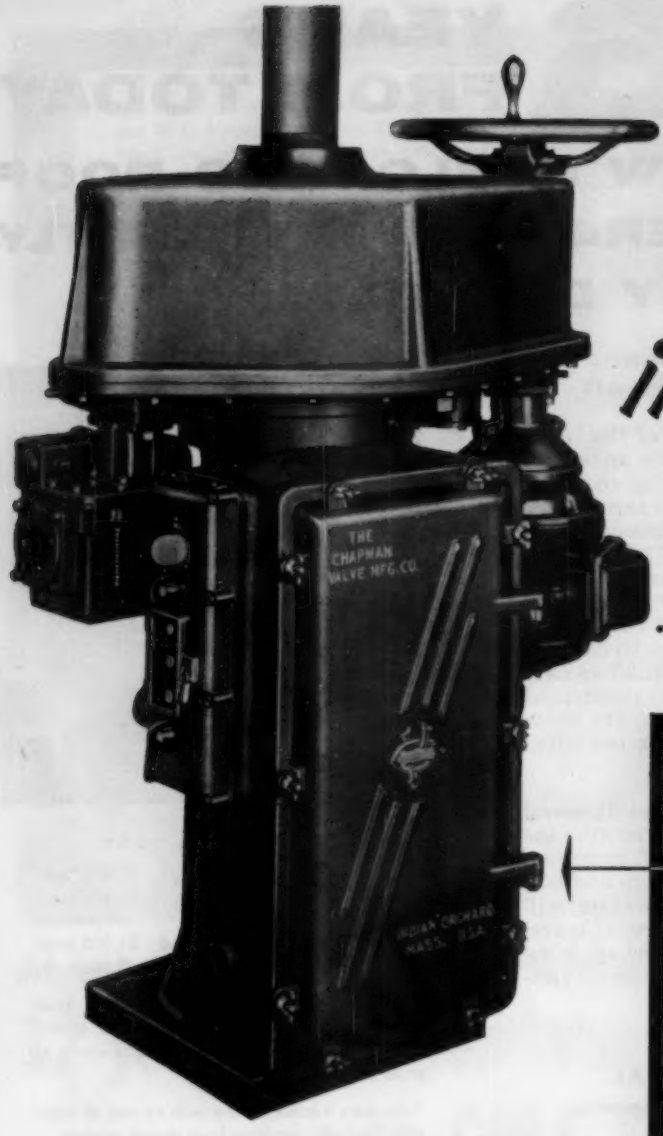


2 TO 1 *in Your favor*

CHAPMAN MOTOR UNITS

...for Valves, Floorstands, and Sluice Gates

It's a matter of simple mathematics. Take any one of Chapman's Motor Units and look it over carefully. You'll find approximately half as many parts as with any other make. This means the chances of cutting maintenance costs are two to one in your favor.

The odds can be even better. With Chapman Motor Units, you not only get simplified design, you also get sturdy construction and smooth, accurate performance over a longer period of time. There's no drift. Backlash is low. An accurate micrometer-controlled limit switch keeps seat tightness at any predetermined level.

Two points more — with Chapman Motor Units there's no trouble with either operating positions or operating conditions. Rugged stub-tooth gears require no grease or oil . . . operate at any angle . . . and the complete unit is not only weatherproof. It's *steam tight*.

Even on installation there's a chance of saving money with Chapman Motor Units. When used with floorstands they are completely wired at the factory . . . ready to connect and work. It's an easy, simple, low-cost job.

Chapman Motor Units for valves, floorstands, and sluice gates are outlined in full in our Catalog 51. If you don't have it, write for it, right now.

THE CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASS.

Now despite skyrocketing costs... International gives you

... UP TO 24% MORE FOR YOUR POWER DOLLAR

IN 6 NEW CARBURETED POWER UNITS!

Your choice of fuel

International's adaptable design permits you to take advantage of your local fuel situation and select either gasoline, LPG or natural gas equipment in all six power units.

Now...you can get up to 24% more for your power dollar! International gives you this horsepower bonus, plus additional *new* savings on fuel, and *extra* life in six new, heavy-duty, 6-cylinder carbureted power units, from 68 to 133 net hp.

Horsepower increases and lower prices result from money-saving mass-production techniques unrivalled in the industry. Three of the power units, the U-264-6, U-308, and U-370 are *special* adaptations of heavy-duty International truck engines—proved for top *worry-free mileage*, and *record ton-mile economy!*

So, compare low first cost per working hp of these new International units with any other make. And compare such International *bonus* features as positive, unfailing lubrication through rifle-drilled oil passages... famous International valve-in-head operating efficiency ...power-smoothing, counter-balanced forged crankshafts ...and positive, "filter-clean" crankcase ventilation. Prove you'll get more dependable hp per dollar...more profits to depend on from every dollar you invest. Compare soon—see your International power unit distributor.

Brief Specifications (Gasoline)*

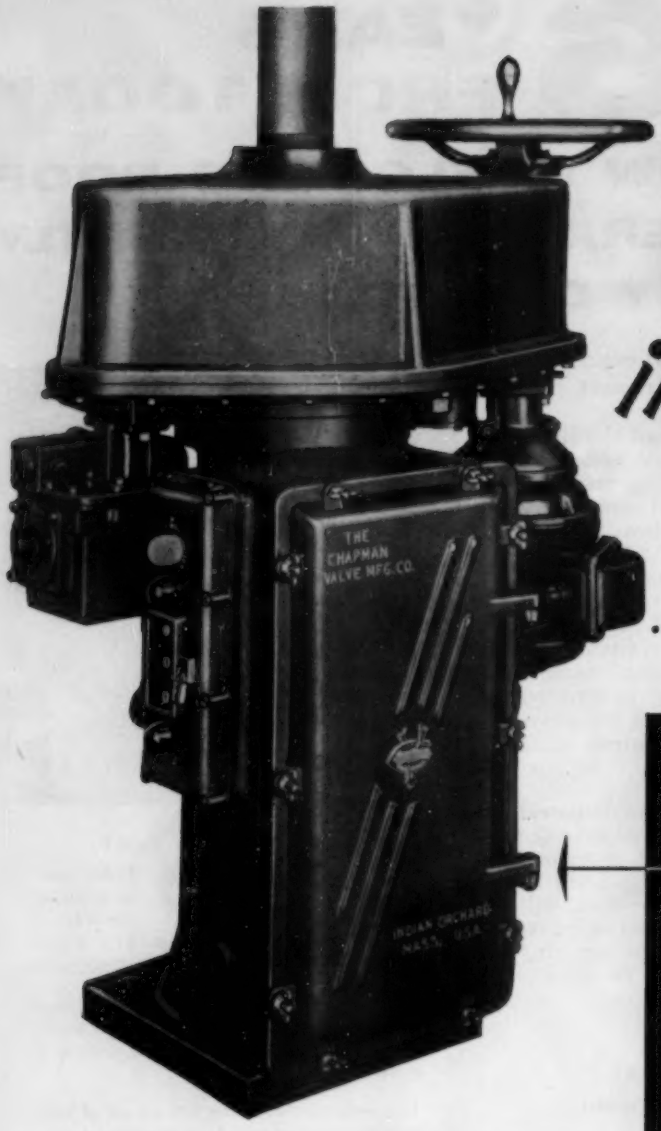
Model	Net hp and rpm	Max. torque lbs.-ft.	Displacement	Bore & Stroke
U-320	68 @ 2400	177	220.5	3⅞x3¹¹⁄₁₆
U-264-6	78 @ 2400	192	264.3	3¹¹⁄₁₆x4⅛
U-308	87.5 @ 2400	229.5	308.2	3¹³⁄₁₆x4½
U-372	104 @ 2200	288	372	4⅜x4⅛
U-450	126 @ 2200	323	450.9	4⅜x5
U-501	133 @ 2200	384	500	4½x5¼

*Complete specifications and ratings on LPG and natural gas available on request.

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Crawler and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

International Harvester Company
180 North Michigan Avenue, Chicago 1, Illinois



2 TO 1 *in Your favor*

CHAPMAN MOTOR UNITS

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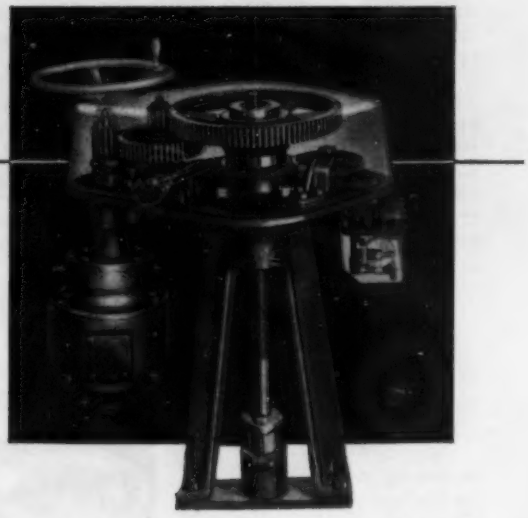

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THE CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASS.

Now despite skyrocketing costs... International gives you

... UP TO 24% MORE FOR YOUR POWER DOLLAR

IN 6 NEW CARBURETED POWER UNITS!

Your choice of fuel

International's adaptable design permits you to take advantage of your local fuel situation and select either gasoline, LPG or natural gas equipment in all six power units.

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U-501	133 @ 2200	384	500	4½x5¼

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A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Crawler and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

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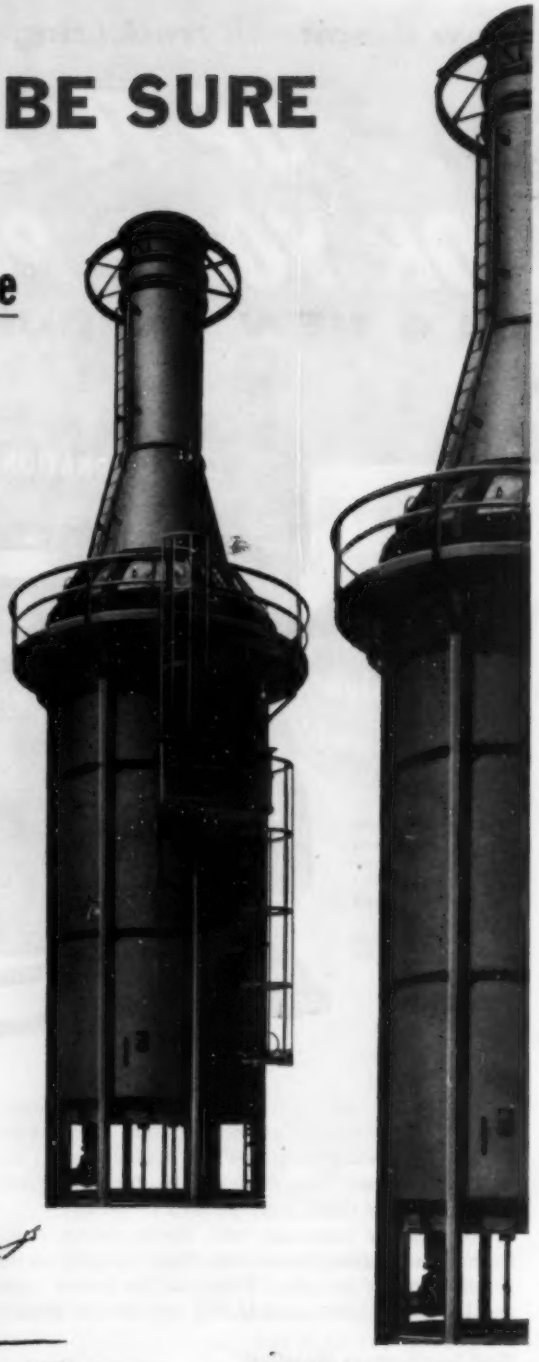
YOU, too, CAN BE SURE

petrochem-isoflow furnaces

are most economically desirable

by any comparison

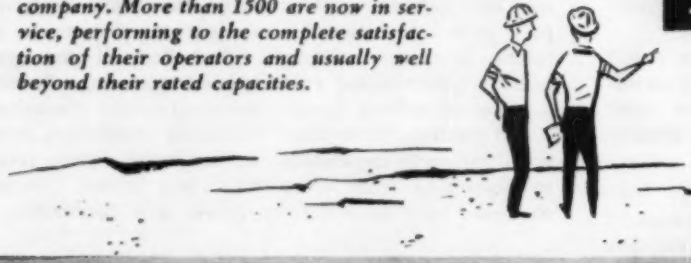


Whenever *all* the specifications and *all* the operating requirements are applied to direct-fired furnace design, you can be sure PETROCHEM-ISOFLOW FURNACES will be found most economically desirable, by any comparison.

In making comparisons it is essential to take these factors into consideration:

1—Average radiant transfer rate.
2—Maximum deviation from average radiant transfer rate.
3—Average and maximum transfer rate in convection section.
4—Maximum tube wall temperature, radiant or convection.
5—Maximum efficiency with specified excess air.
6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube.
7—Overload and corresponding transfer load.
8—Design to provide: structural column supports—Ladders—Platforms—Tube Removal facilities, etc.
9—Degree of assembly; of the furnace structure and of the heating surface.

When you specify PETROCHEM-ISOFLOW FURNACES . . . you'll be in good company. More than 1500 are now in service, performing to the complete satisfaction of their operators and usually well beyond their rated capacities.



PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

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TUBE-TURN

In small piping too you get big savings by welding

Five years ago, the generally accepted practice among engineers and contractors was to weld non-critical pipe larger than 2-inches and thread the smaller sizes. Today, that dividing line has gone down; much piping as small as ½-inch is now being welded. In small piping as in large, the big reason for welding is *to save money* . . . in installation cost, in material cost, in maintenance cost. See next page for typical results. For the small pipe jobs, too, you get the *most for your money* when you specify and buy TUBE-TURN* Welding Fittings and Flanges. Your nearby Tube Turns' Distributor can give you speedy service in sizes from ½-inch to 42 inches!

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1, KENTUCKY

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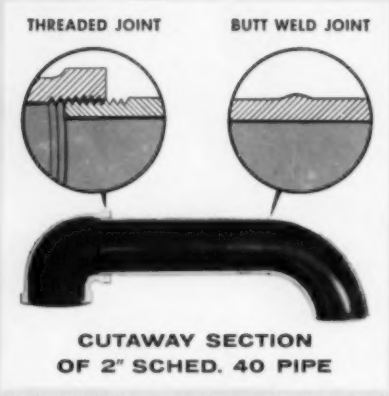
*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

WHY IT PAYS...

SMALL DIAMETER PIPING... *why it pays to specify welded construction with* TUBE-TURN *Fittings*

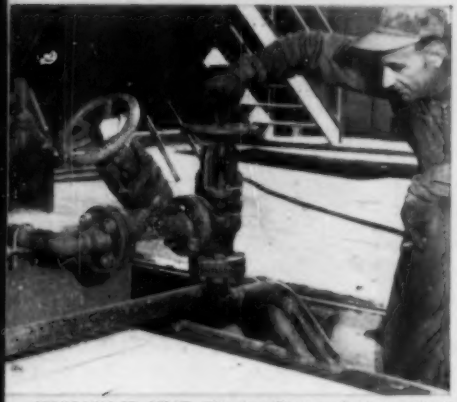
NEVER LEAKS. Welded joints are permanently as strong and leakproof as the pipe itself. Photo shows welded lube oil lines for one of four diesel engines, replacing threaded lines which leaked. If welded in first place, would have saved $4000 replacement cost. Pipe is 2½" with TUBE-TURN Fittings.



CUTAWAY SECTION
OF 2" SCHED. 40 PIPE

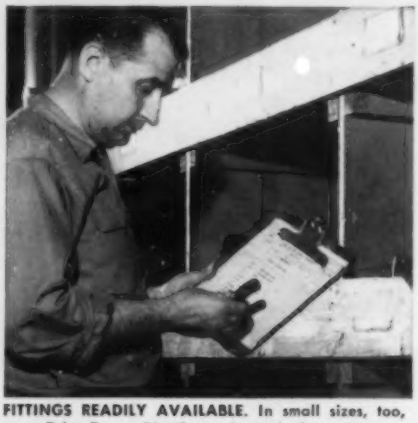
SAVES MATERIAL. Threading cuts half of pipe wall away as shown. The welded joint is as strong as the pipe. An installation of Schedule 40 pipe, welded, is stronger than Schedule 80 threaded. Hence, for equal strength welded piping can cut material costs 30-50%.

TAKES LESS TIME to weld than to thread pipe above 2" and about equal time for smaller sizes, according to recent tests on hundreds of joints made by many different pipe fitters. Welded joints in 1½" piping such as the school heating line shown, averaged 7 minutes compared to 8 minutes for threading and tightening fitting.



IS COMPACT, NEAT. This installation of 1½" and 2" boiler blow-off piping shows ability to nest welded lines close together for better layout and streamlined appearance. Also, insulation, where needed, is easier to apply.

TOOLS ARE SIMPLE. Small, inexpensive welding outfits can cut, weld, heat to bend, solder or braze. They are easy to haul to job and simple to use. All pipe for this factory radiant heating system was fabricated on the site.



FITTINGS READILY AVAILABLE. In small sizes, too, your Tube Turns Distributor is stocked to give you prompt, efficient service. Call him on *all* your needs in welding fittings and flanges . . . from ½" to 42".

MORE INFORMATION—This bulletin gives helpful information on "The Economics of Welding Small, Noncritical Pipe". Mail the coupon for your free copy.

TUBE TURNS, Dept. K-6
224 East Broadway, Louisville 1, Kentucky

Please send free copy of "Economics of Welding Small, Noncritical Pipe".

Company Name _____

Company Address _____

City _____ *Zone* _____ *State* _____

Your Name _____

Position _____

Available from your nearby TUBE TURNS' distributor

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TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

EFCO's Four Point Program Provides:

- **service-proved engineering design**
- **guaranteed job ratings**
- **complete fabricating facilities**
- **technical service before, during and after installation**

One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

ASK OUR GULF COAST CUSTOMERS — THEY KNOW US WELL

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EFCO HEAT TRANSFER EQUIPMENT

Engineers and Fabricators, Inc.

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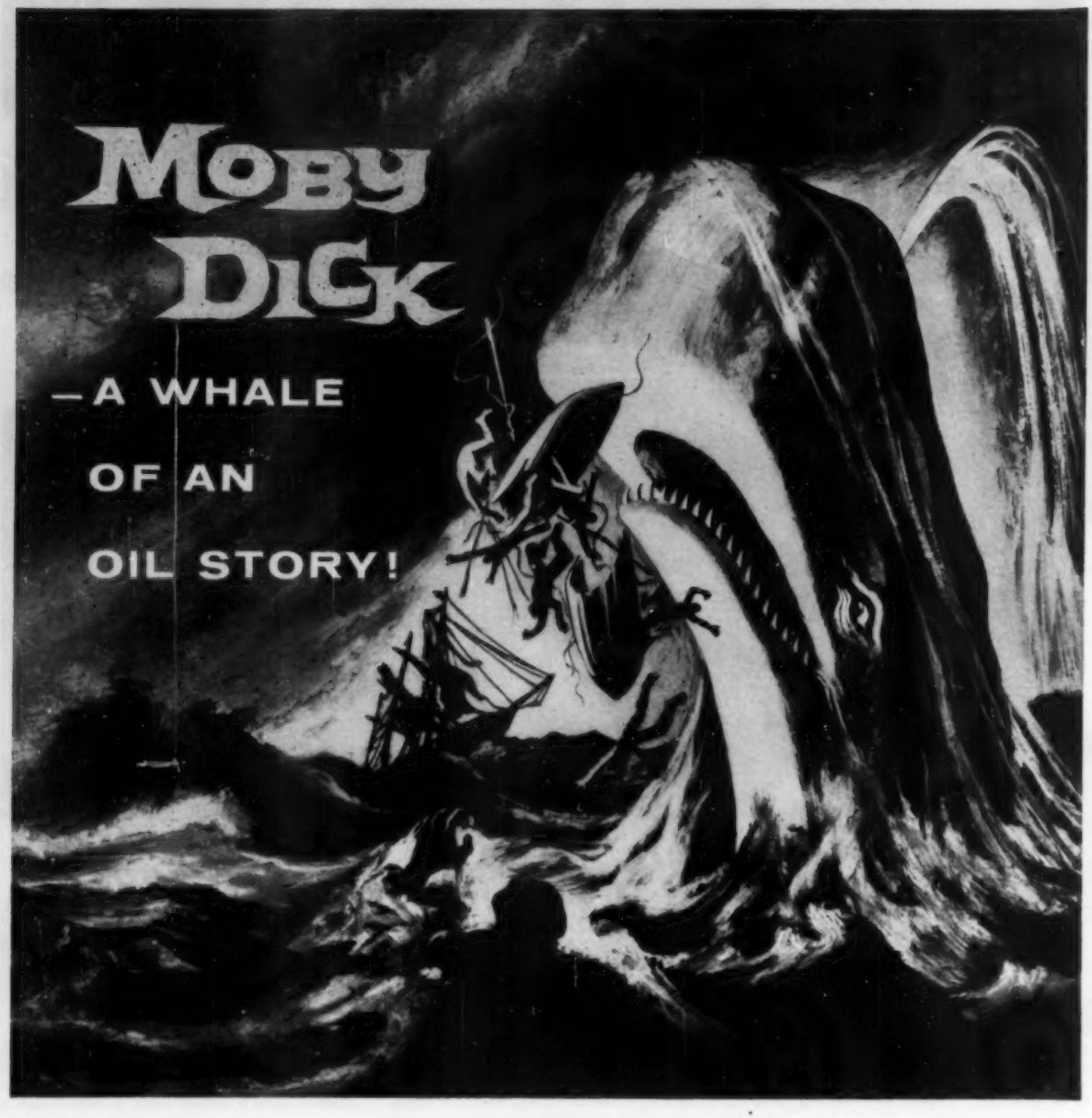
EFCO

6100

GREGORY PECK starring in MOBY DICK • A Moulin Production—In Technicolor • Presented by Warner Bros.



Whales have been producing oil for centuries . . . but never has oil helped produce a whale . . . that is, until the cinema's Moby Dick.

Where's the oil in Moby Dick? In its hundreds of square feet of man-made skin and gallons of crimson blood. Both are made with products derived from petroleum through the miracle of petrochemistry.

A stellar offspring of the oil industry, petrochemistry transforms crude oil into hundreds of petroleum chemicals which in turn, become the vital raw materials for countless new products of everyday life: Miracle fibres, "rubber" paints, and scores of plastics and drugs.

As a leading member of this dynamic industry, Cities Service is now substantially expanding its petrochemical activities to meet steadily growing demand, and continue petrochemistry's march toward greater frontiers.

But this demand for Cities Service products is not confined to petrochemicals. It sweeps the spectrum of Cities Service fuels and lubricants and echoes in new oil reserves and refining facilities, new pipelines and tankers, new stations and dealers, and constant improvement in product quality.

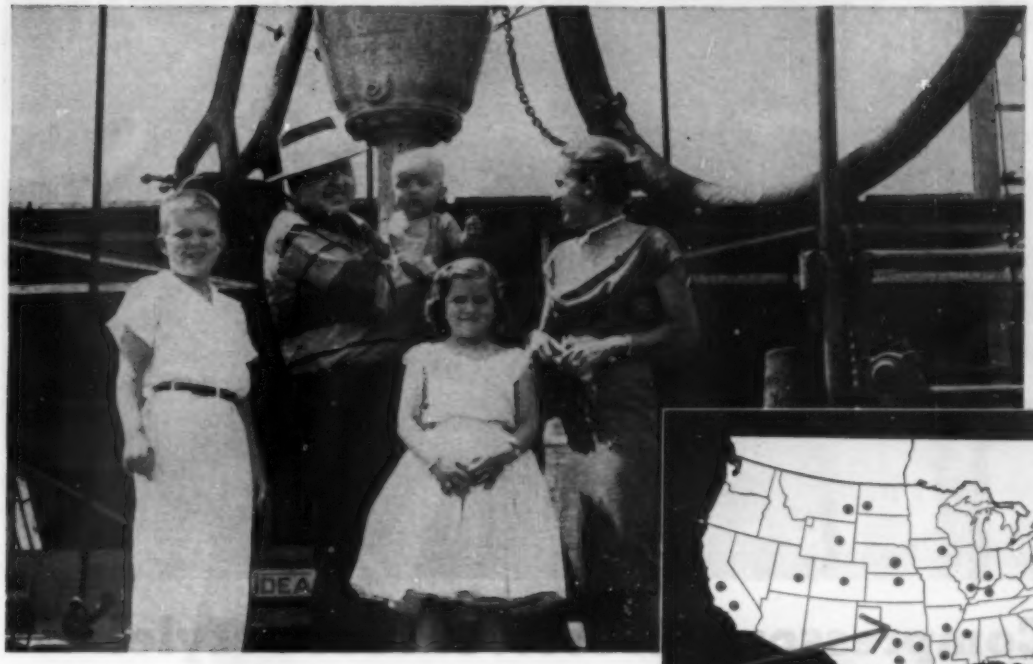
Or, to put it more simply, it means that bigger and bigger things are coming your way from Cities Service—for nearly half a century, a leader in petroleum progress.

CITIES SERVICE

Progress through Service

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Oil Financing from the **FIRST** *in* **DALLAS** *goes where you go...*



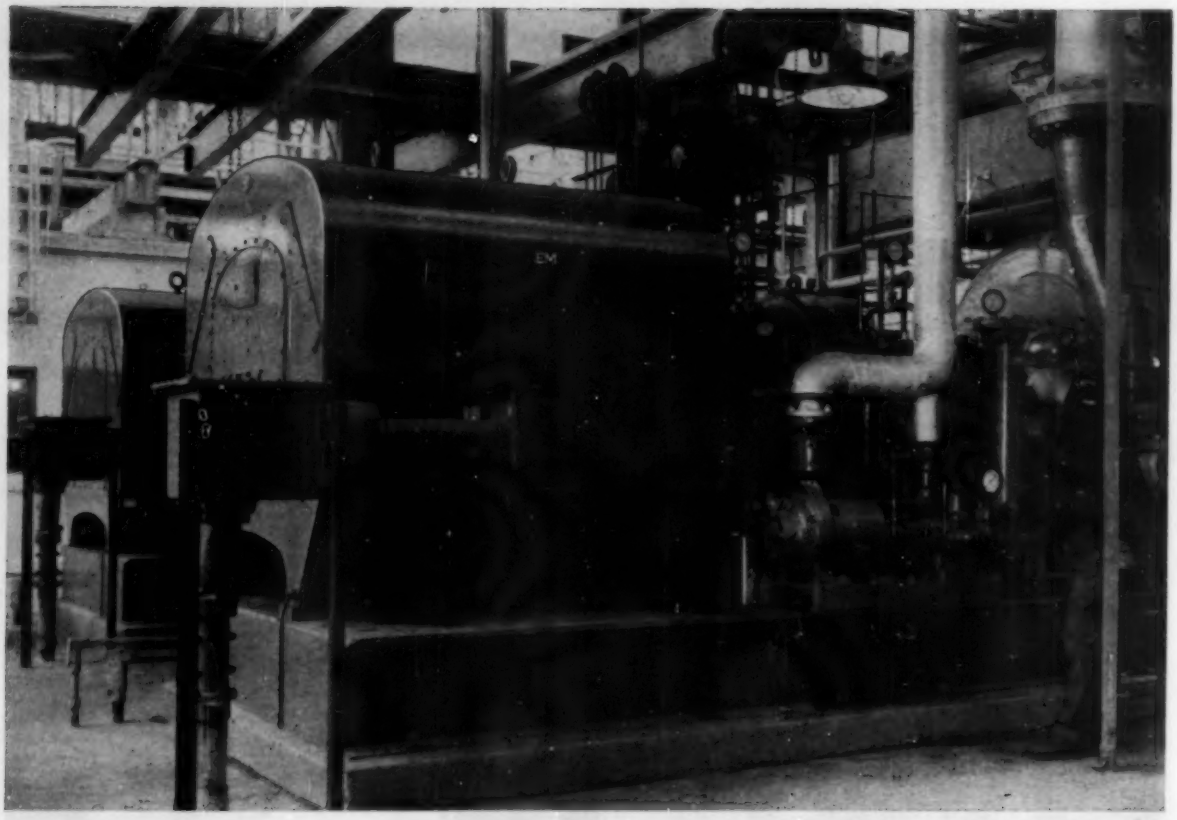
Mr. and Mrs. Quintin Little and family on site of Harrell Well No. 1, Doyle Field, Stephens County, Oklahoma. An oilman well known to all Independents, Mr. Little is a longtime customer of the FIRST in DALLAS.

Specialized experience, organization, and resources to help you with practically any kind of need for "working money".

FIRST NATIONAL BANK IN DALLAS

Member Federal Deposit Insurance Corporation

put FIRST financing in your own oil future



Compressor drives . . . outdoor style!

● Right outdoors in Canadian weather are these two E-M Weather-Protected Induction Motors at the Vancouver, B. C. refinery of Imperial Oil Co., Ltd.

Rated at 1500 hp, 1750 rpm, the Motors drive centrifugal compressors and are among the largest such drive units built to date for outdoor installation without total enclosure.

This installation demonstrates two important advantages of E-M outdoor drives:

FIRST, E-M Weather-Protected Motors do not require expensive indoor floor space.

SECOND, their weather-protected construction allows them to be installed outdoors, away from explosive atmospheres.

E-M Weather-Protected Induction Motors have many other advantages as well. No special foundations are necessary. The protective hood sheds falling or blowing precipitation. Screened air intakes located above the motor feet prevent the entrance of refuse. And because ventilating air enters at low velocity, suspended particles are dropped before they reach vital motor parts.

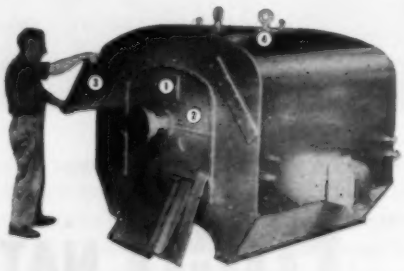
Special "blow-through" passages provide a by-pass for high velocity gusts of wind. Protective coatings guard the motor interior and exterior from weather hazards. Even with this extensive protection, access is quick and simple without dismantling the motor.

Find out how these E-M Weather-Protected Motors, located outdoors, can cut installation costs and reduce danger on pump or compressor drives. Call your nearest E-M Sales Engineer for full information. Write the factory for E-M Synchronizer No. 40, the special oil industry issue, showing Weather-Protected Motor installations.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

PROTECTION WITH ACCESSIBILITY!

1. Door plates unlock quickly for handy access to bearing filler cap and oil ring inspection hole.
2. Large end plates permit bearing inspection, air-gap measurement, or blow-out of interior.
3. Intake air filters are easily removed for inspection or replacement.
4. Entire "weatherized" steel hood lifts by eyes for "all over" cleaning.



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E-M

Specialists in making motors do exactly what you want them to

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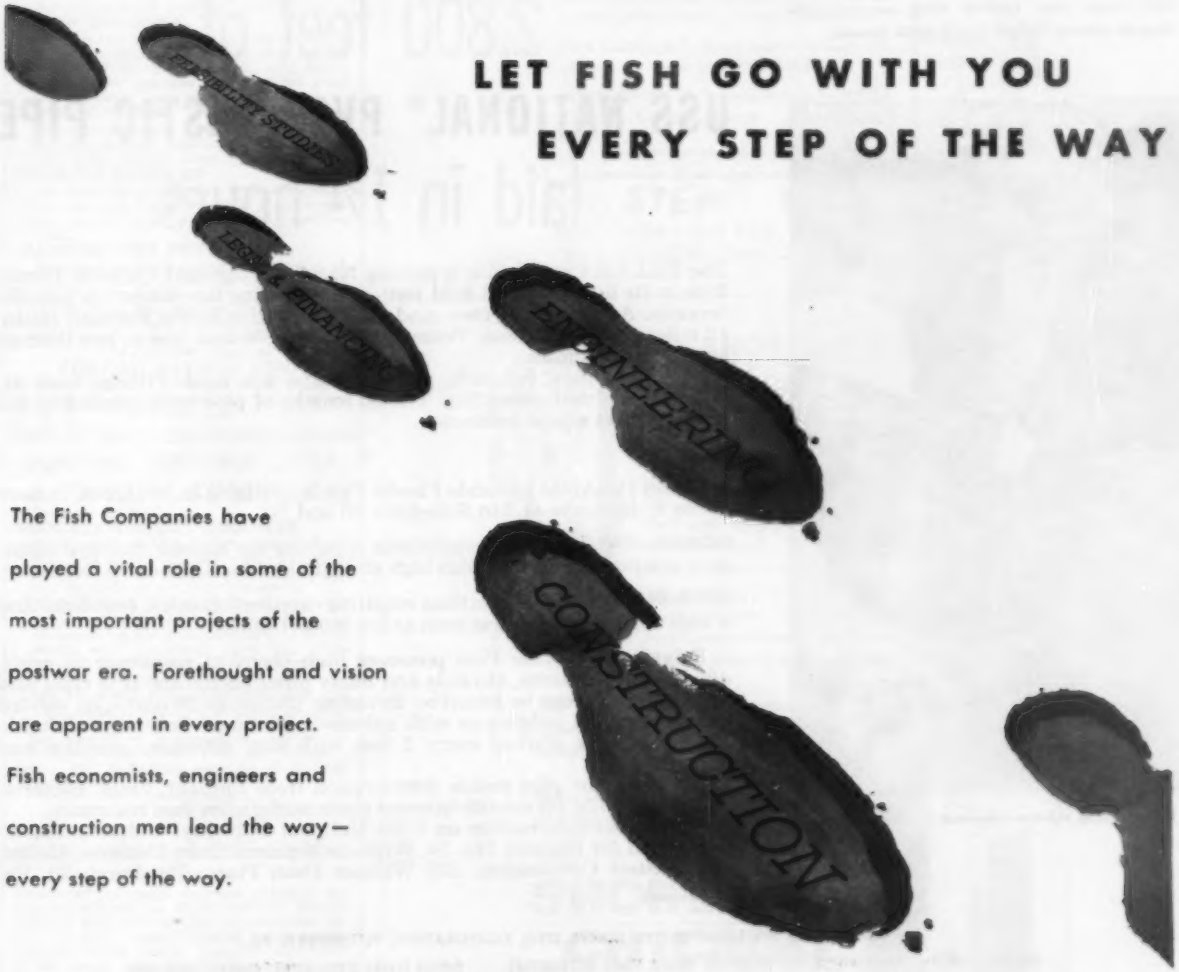
ENGINEERING CORPORATION

HOUSTON, TEXAS



LET FISH GO WITH YOU EVERY STEP OF THE WAY

The Fish Companies have played a vital role in some of the most important projects of the postwar era. Forethought and vision are apparent in every project. Fish economists, engineers and construction men lead the way—every step of the way.

Affiliated Companies

FISH SERVICE CORPORATION

FISH NORTHWEST CONSTRUCTORS, INC.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Thirty-foot lengths of 2-inch, Schedule 40 National PVC Plastic Pipe. Each of these easy-to-handle lengths actually weighs less than 20 pounds.

Fitting being solvent-cemented in place.

2,800 feet of
USS NATIONAL* PVC PLASTIC PIPE
laid in 1¾ hours

The TXL Oil Corporation is putting National Polyvinyl Chloride Plastic Pipe to its first rough oil field test—as a gathering line subject to paraffin deposits. A pipe laying crew made the installation in the Permian Basin, 12 miles south of Odessa, Texas, laying the 2,800-foot line in less than an hour and 45 minutes.

Normal impact, two-inch, plain-end pipe was used. Fittings were attached by solvent cementing. The 90 lengths of pipe were coupled at the rate of almost a joint a minute.

★ ★ ★

National Polyvinyl Chloride Plastic Pipe is available in two types, in sizes ½" to 6" inclusive and in Schedules 40 and 80.

NORMAL-IMPACT—for installations requiring the highest chemical resistance attainable, together with high strength and excellent creep resistance.

HIGH-IMPACT—for installations requiring excellent chemical resistance and a high degree of toughness even at low temperatures.

Polyvinyl Chloride Pipe possesses high chemical resistance to acids, alkalis, salt solutions, alcohols and many other chemicals. It is rigid and light weight . . . can be joined by threading (Schedule 80 only), by solvent cementing, heat welding or with adhesives. National Polyvinyl Chloride Plastic Pipe is marked every 2 feet with size, schedule, pressure and temperature.

Nontoxic, the pipe resists deterioration from sunlight, fungi, bacterial action and soils. Its smooth internal surface offers low flow resistance.

For further information on USS National Polyvinyl Chloride Plastic Pipe, send for Bulletin No. 24. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

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NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.

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USS NATIONAL *plastic* PIPE

UNITED STATES STEEL

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PETROLEUM ENGINEERS

Experienced graduate engineers for immediate openings in Saudi Arabia and New York City. For engineering work in development, production, drilling, process, and oil and gas engineering on primary and secondary recovery problems.

RESERVOIR ANALYST FLUID

With degree in Physical Chemistry or Chemical Engineering plus 5 years' petroleum production engineering which would include 2 years' study of reservoir fluid behavior.

Salaries commensurate with training and experience. Write outlining personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 117
ARABIAN-AMERICAN OIL COMPANY
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NEW YORK 22, NEW YORK

Pontiac Eastern Corp.

A new, complete refinery currently under construction near Hattiesburg, Mississippi, includes Thermafor Catalytic Cracking, Fluid Coking, Sulfuric Alkylation, Platforming, Unifining and Sulfur Recovery.

Applications are now being taken for the following positions:

PLANT SUPERINTENDENT
A mature and responsible person with thorough training and broad experience in both operation and maintenance of petroleum refinery equipment to have charge of both of these functions in the refinery, the pipe line and the terminal.

CHIEF ENGINEER
An engineer with general technological experience to have charge of both process design and mechanical design work. Scope of position is open and dependent on available person.

CHIEF CHEMIST
Responsible person with experience in petroleum product blending and familiarity with latest refinery laboratory methods.

PROCESS FOREMAN
An operations supervisor of broad experience to work under the Plant Superintendent and to be in charge of all operating units.

MAINTENANCE FOREMAN
An experienced supervisor familiar with all types of refinery equipment to work under the Plant Superintendent and to be in charge of maintenance and small construction in the refinery, pipe line and terminal.

Write, giving resumé including experience with processes listed, to

PONTIAC EASTERN CORP.
P. O. Box 1581, Corpus Christi, Texas
Applications for other positions will be taken at a later date.

PONTIAC REFINING CORP.

A well established growing independent refiner has three openings for experienced refinery personnel:

PROCESS DESIGNS ENGINEER
With minimum of five years design experience and ability to work with mechanical design engineers. Scope of position is open and depends on available person.

OPERATIONS ANALYST
A general technologist with understanding of processing and ability to evaluate charge stocks and processing operations. Also requires thorough familiarity with product blending and the economics involved.

SAFETY AND FIRE SUPERVISOR
This position requires a person familiar with refinery operations and the safety and fire hazards of refineries, as well as the ability to organize and carry on a complete safety and firefighting program in a small organization.

Write, giving resumé, to
PONTIAC REFINING CORP.
P. O. Box 1581, Corpus Christi, Texas

ENGINEERS

Important permanent positions available for MECHANICAL or ELECTRICAL ENGINEERS with manufacturer of equipment for the petroleum industry located in the southwestern United States. Required experience in the design and development of automatic control equipment. Positions available in Sales and Engineering departments. Salary open. Send resumé to Box 185, PETROLEUM ENGINEER, P. O. Box 1589, Dallas, Texas.

CELLOPHANE FLAKE

Carload Quantities Available
Price List and Samples Upon Request
CLINTON PALLET CO., INC.
615 South First St., Clinton, Iowa
CALIFORNIA REPRESENTATIVE
MR. H. R. SMITH
1234 West Sant Clara Ave., Santa Ana, Calif.

ENGINEERS

Engineers are in demand in the Gulf Coast area. Benefit by our experience in serving the Petroleum and Chemical Industries through the years. Salaries $6,000 to $12,000 up.

QUINBY EMPLOYMENT SERVICE
"Houston's Oldest — Uunder One Owner"
409 Bankers Mortgage Building
Houston 2, Texas

OVERLOOKING THE CONGRESS AND THE CONRAD HILTON

CHICAGO'S Newest HOTEL • • • The HARRISON

Just off Michigan Boulevard on Harrison Street

FOR CONVENIENCE—Ideal downtown location. Coffee Shop . . . reasonable prices.

FOR COMFORT—Every room with bath, circulating ice-water and FREE RADIO.

FOR ECONOMY—Home of famous HOOSIER ROOM . . . Cocktail Lounge . . . Entertainment

Air-Conditioned Rooms Available

600 Car Garage UNDER ONE ROOF

Rooms From $5

Special Family and Group rates

STEP RIGHT FROM YOUR CAR INTO THE HOTEL LOBBY

The **SHORELAND Hotel** offers every facility for

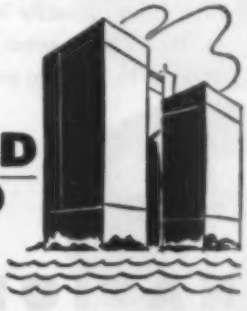
SUCCESSFUL CONVENTIONS

AIR-CONDITIONED MEETING ROOMS

In a resort atmosphere with all the conveniences of a downtown hotel. 15 beautiful, modern meeting and dining rooms all air-conditioned to accommodate conventions of up to 1,000 persons. Largest hotel nearest Midway airport. 10 minutes from Loop. Near all sports, entertainment, the Museum of Science and Industry, University of Chicago, and White Sox Ball Park.

1,000 luxurious rooms and suites—all overlooking Lake Michigan. Television in every room. Famous for fine food and beverages. Ample Free Parking.

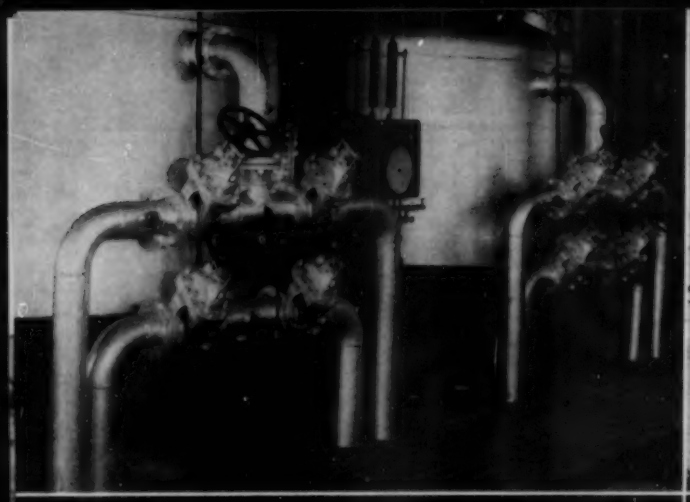
Write for further information and descriptive folder.



The **SHORELAND CHICAGO**

55th and SOUTH SHORE DRIVE
TELEPHONE . . . . PLaza 2-1000

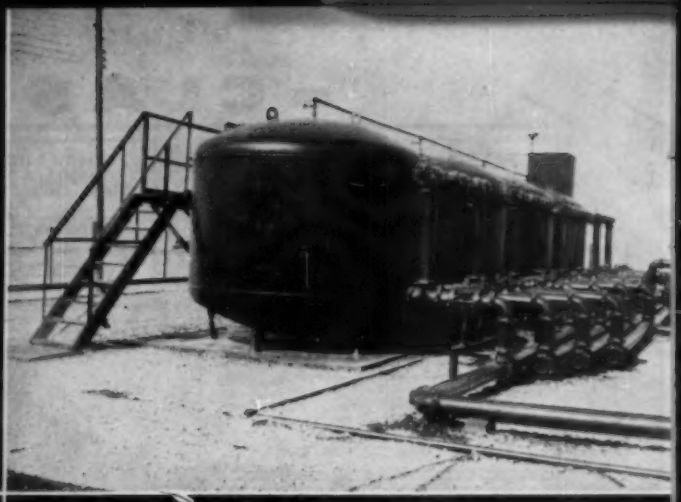
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



2-8′ x 5′ 40 PSI W.P. National Filters in Illinois Water Flood

•

4-8′ x 5′ 60 PSI W.P. National Filters in gasoline plant near Schuler, Arkansas



8-75 PSI W.P. National Filters in Eastern Oklahoma Water Flood

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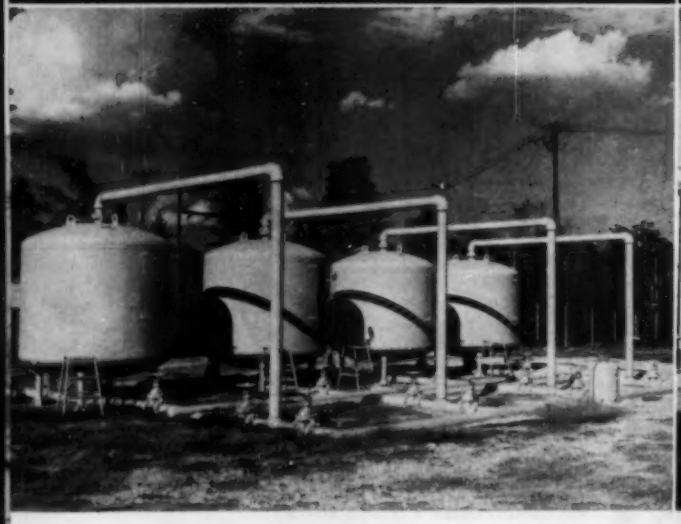
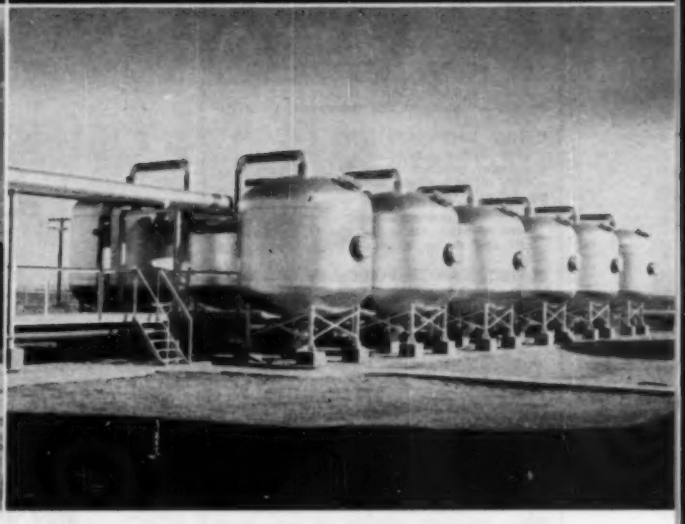
Battery of 200 PSI W.P. National Filters in West Texas Water Flood





National RAPID MECHANICAL FILTERS

For Water Flood and Water Disposal

National Rapid Mechanical Filters are designed for both open and closed water disposal systems and water flood projects. Filteration capacity is from 2 to 3 gpm per sq. ft. of filter area. Backwash rates are from 12 to 20 gpm per sq. ft. of filter area.

National Filters are furnished in the following sizes:

4′ X 5′ • 5′ X 5′ • 6′ X 5′ • 7′ X 5′
8′ X 5′ • 10′ X 5′ • 12′ X 5′

Our Engineering Department welcomes inquiries concerning your water disposal problems.

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

IT'S BRAND NEW!

The O-C-T UNIVERSAL TUBING HEAD

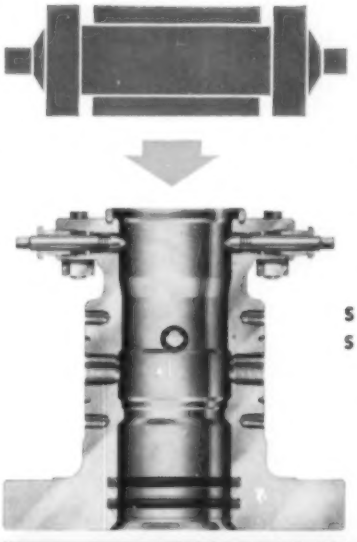
. . with 6 interchangeable dual string and single string tubing hangers!

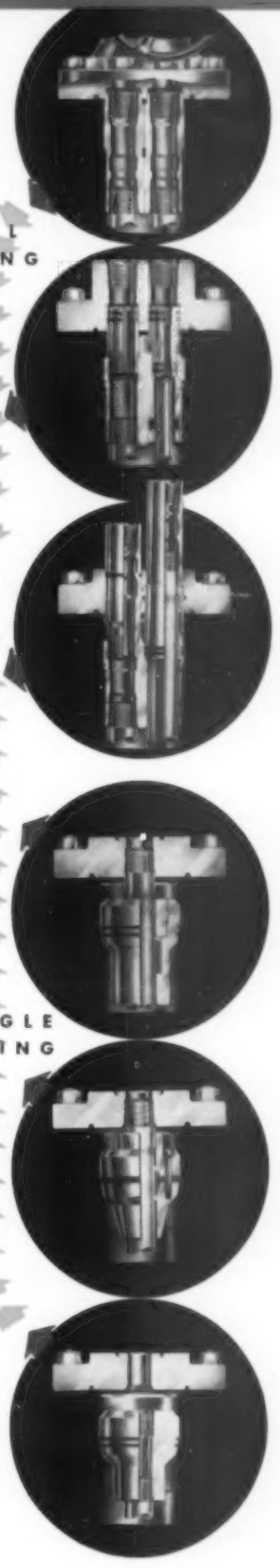
The new O-C-T universal tubing head is available with a complete range of interchangeable tubing hangers for both dual and single strings. Last minute changes in completions can be made without changing tubing heads or using special attachments. If only one producing sand is found in a proposed dual well, the well may be completed by using a single string hanger. If a second sand is found in a well originally scheduled for single completion, the well may be completed with a dual hanger instead of the single hanger originally contemplated.

The O-C-T universal tubing head is equipped with two retractable aligning screws which are used to align the dual hanger with respect to the head itself. These aligning screws are retracted when single string hangers are used.

Safety is assured, since all hangers are run through, landed and locked in place prior to the removal of blowout preventers. Once the head has been installed, all seals can be field tested through test ports located in the flanges.

This universal head is available in 600 through 2900 series and flange sizes from 6" to 10". If an operator does not desire to remove the existing tubing head in order to dually complete a well, an adapter is available.





Any of six interchangeable hangers may be landed and locked in place through blowout preventers

All seals may be tested by a single application of pressure through a test port in the top adapter flange

O·C·T

OIL CENTER TOOL CO.

Export Representatives: South America — East West Oiltools, C. A., Del Lago Hotel, Maracaibo, Venezuela. Address Export Inquiries for All Other Countries to P. O. Box 3091, Houston, Texas.

"y' just don't push me around—see!"

LANE-WELLS HYDRAULIC HOLD DOWN TOOL HOLDS PACKERS IN PLACE AGAINST 6,000 PSI DIFFERENTIAL PRESSURE

Small though it is, this ingenious new Lane-Wells tool has proved its value in some right tough situations. It's actuated by hydraulic pressure—the higher the pressure, the harder its 24 pistons push out, the tighter its 96 hardened points grip the casing.

While it's rated to hold against 6,000 psi, our tests indicate holding power higher than that. Field tests on acidizing jobs, fracturing jobs, high-pressure formation testing, straddle packer assemblies and the like haven't been able to budge the packer assemblies that used the Lane-Wells Hydraulic Hold Down Tool. Every time, the tool has held, yet released easily when pressure was slacked off. Just to make sure, the Hydraulic Hold Down Tool has been made as corrosion-resistant as possible by plating it with non-porous nickel plate.

If you have problems of high pressure, include a Lane-Wells Hydraulic Hold Down Tool in your packer assemblies, whomp up the pressure, and relax—the Hold Down Tool won't!

Tomorrow's Tools—Today!®

LANE WELLS COMPANY

Los Angeles • Houston • Oklahoma City • Lane-Wells Canadian Co. in Canada • Petro-Tech Service Co. in Venezuela

General Offices, Export Office and Plant • 5610 So. Soto St. • Los Angeles 58, California

Of Things To Come . . . In Oil

DEEP DRILLING PROSPECTS IN WEST TEXAS for next year look very bright now. Several majors have a number of tests, some to possibly 20,000 ft, planned. Stanolind, Shell, Humble, and some large independents will be probing deep in the Val Verde and Delaware Basins in '57.

NEW CRUDE LINE FOR PERMIAN BASIN beyond drawing board stage, according to reliable sources. Plans call for a big inch line delivering about 300,000 bbl daily to the Gulf Coast. Interested parties are Magnolia, Atlantic, Phillips, and Cities Service. Surveyors are already on the job for a right-of-way. Construction will probably get underway next year.

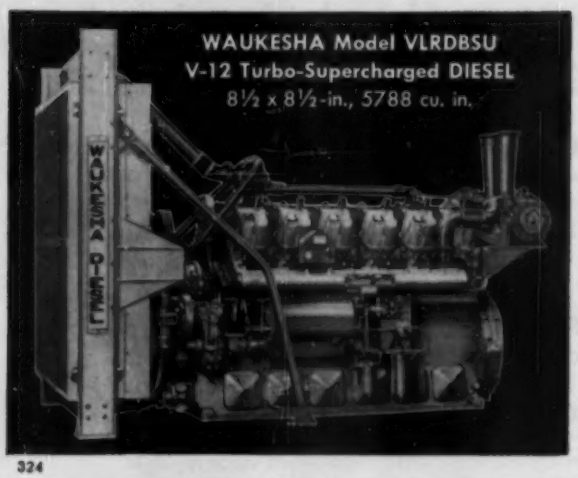
U. S. WILL INCREASE OIL PRODUCTION TO MATCH DEMAND — even if domestic operators continue to complete wells in the next 10 years at no more than the 1956 rate, says Morgan Davis, Humble Oil & Refining, speaking before Society of Exploration Geophysicists. Davis indicates it will be "surprising" if completions in next decade do not exceed present levels; says oil is *not* harder to find now than in the '30s, just costs five times as much to find.

65,000 WELLS WILL BE DRILLED IN U. S. IN 1957, says IPAA President Robert L. Wood, if there are adequate markets and prices. Wells will be drilled only if imports are trimmed, indicated Woods. New holes would cost about $6 billion, in addition to all present expenses, including secondary recovery operations.

NON-EXEMPT CRUDE IMPORTS IN JANUARY AND FEBRUARY will be exceeded by 52,000 bbl per day, enough to warrant "threat to our national security" according to Cabinet fuels policy committee limitations, according to IPAA analysis of import schedules presented to the Texas Railroad Commission. These reports schedule 352,000 bbl of oil per day from sources other than Canada and Venezuela. Import allowable under the committee's new formula for 1957 is about 300,000 bbl per day for the non-exempt crude.

NO MORE STEEL PRICE HIKES — UNTIL NEXT JULY, assures *Iron Age*. "Producers are not going to boost prices — either base or extras," says the steel industry magazine, in spite of rising costs of scrap and coal. Latest increase in steel base price, amounting to $8.50, came last August after wage-agreement providing substantial steelworker benefits over a three-year period.

Brewster-Bartle Drilling Co. Inc. use WAUKESHAS on "Trinity Bay" inland barge on South Louisiana coast



324

● Three VLRDBSU Waukeshas do the drilling and pumping here. They're big... and equipped with exhaust-driven dual turbo-chargers for extra power that's extra-smooth. Rugged for heavy duty, but compact... and yet simple in design for complete reliability with high fuel economy and low upkeep. They're 12-cylinder, 60-degree vee, four-cycle, 5788 cu. in. full Diesels with counterbalanced crankshafts. Send for Bulletin 1663.

For lighting and auxiliary power there are two Waukesha WAKDB 100 KW Enginators. These accurately balanced, conservatively rated Waukesha Diesel engine-driven generator combinations supply a smooth, steady flow of power for continuous duty. Other Waukesha Enginators in capacities from 600 to 50 KW. Send for Bulletins.

WAUKESHA

WAUKESHA MOTOR COMPANY, WAUKESHA, WISCONSIN • NEW YORK • TULSA • LOS ANGELES

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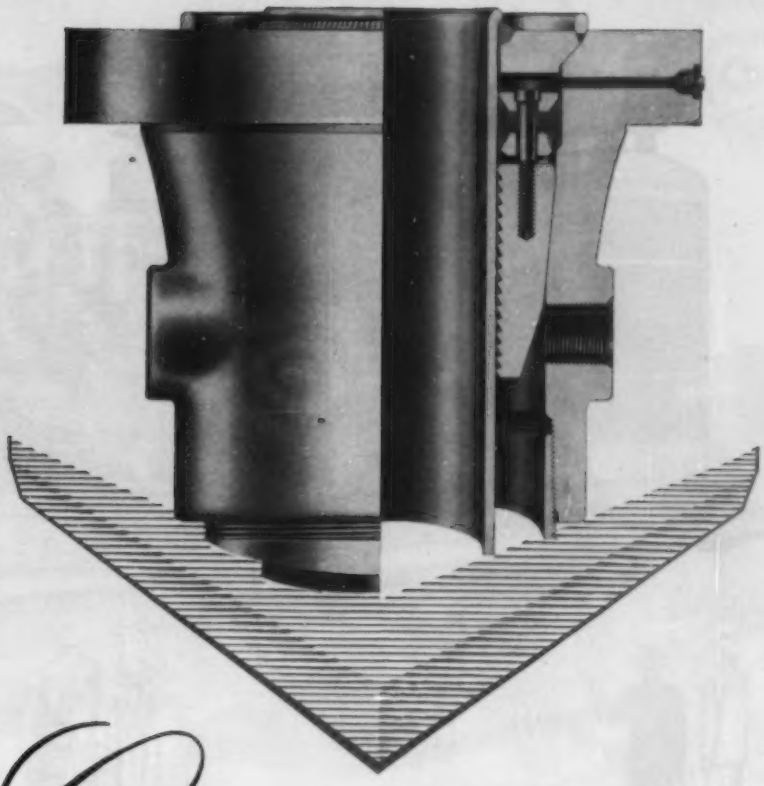


THE *Cadillac* OF CASING HEADS

RECTORHEAD Casing Heads have achieved their place in the industry through the design of the Rector Welding Ring and application of API ring gasket which makes the metal-to-metal seal between strings possible.

This "ring-of-steel" seal not only simplifies high pressure casing head installation, but provides a seal that will not burn out, deteriorate, flow under high pressure or temperature, requires no maintenance or replacement, and eliminates pressure equalization between strings.

The 60,000 Rectorhead Casing Heads, with all-metal, welded seal, installed during the past 25 years, have been a vital factor in "Making the Oil Industry Safer."

Sold through authorized supply stores.

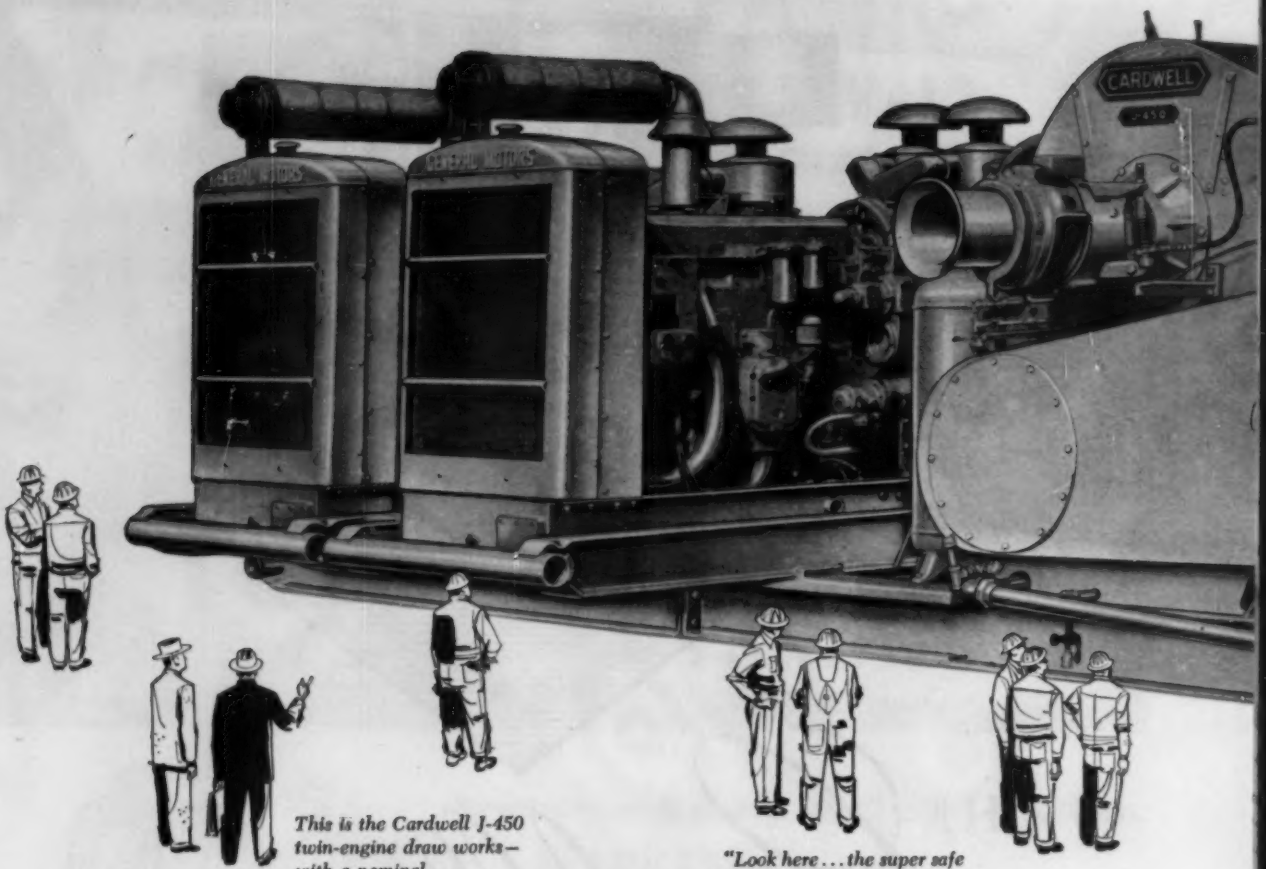
RECTOR WELL EQUIPMENT COMPANY INC

★ MAKING THE OIL INDUSTRY SAFER

1100 NORTH COMMERCE ST. FORT WORTH, TEXAS

Houston Plant: 2215 Commerce St.

REPRESENTATIVES IN ALL ACTIVE FIELDS

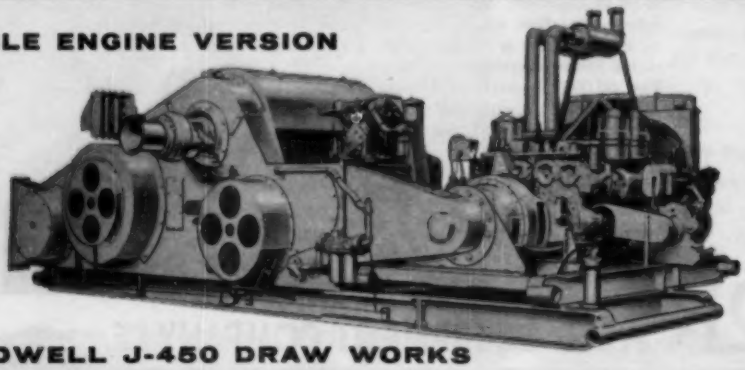


This is the Cardwell J-450 twin-engine draw works— with a nominal 520 input horsepower.

"Look here . . . the super safe cathead shaft permits slow speeds without idling engines or shifting gears."

. . . "the BIGGEST value in

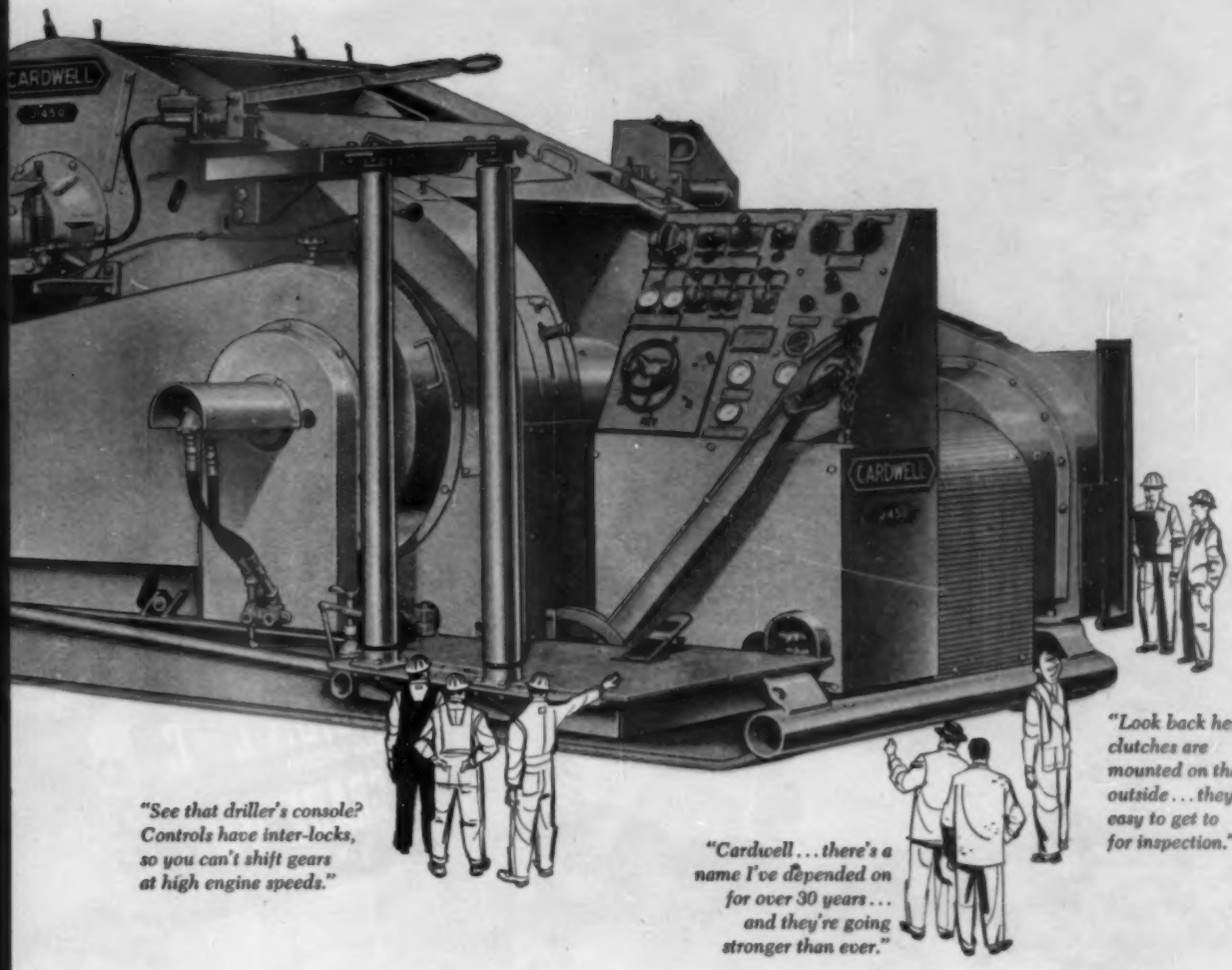
SINGLE ENGINE VERSION



CARDWELL J-450 DRAW WORKS

Single Engine Features

- Torque Converter Driven.
- Air Friction Clutch Drive for Main Drum and Cathead Shaft.
- Serves as split rig, if desired.
- Hoist portion identical to Twin-Engine Model J-450 and adaptable to same accessories.
- Maximum Input Horsepower 520.


CARDWELL
CARDWELL
"See that driller's console? Controls have inter-locks, so you can't shift gears at high engine speeds."
"Cardwell... there's a name I've depended on for over 30 years... and they're going stronger than ever."
"Look back here... clutches are mounted on the outside... they're easy to get to for inspection."

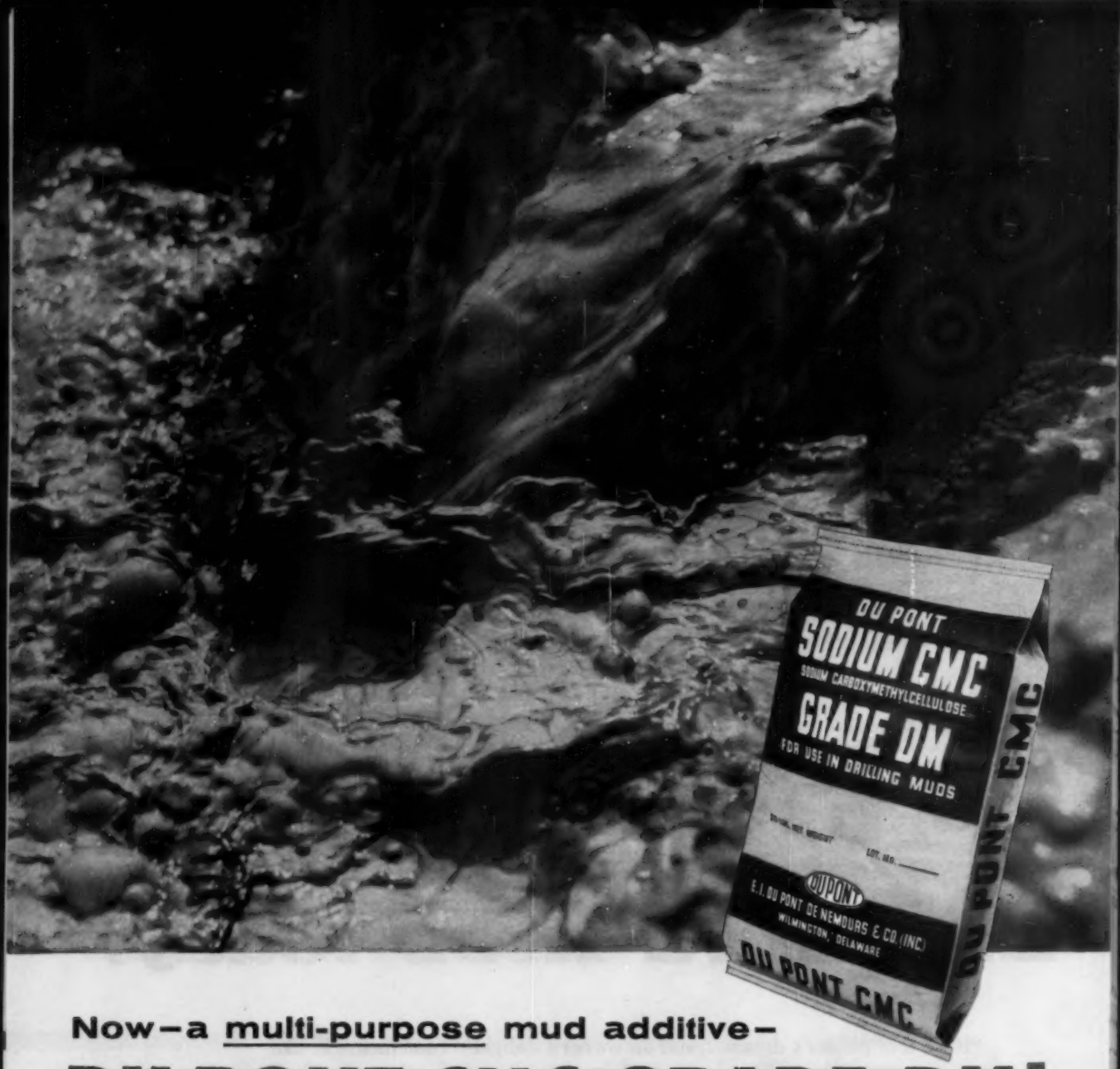
DRILLING RIGS today!"

It's a tool pusher's dream... and an owner's delight! Your men will like Cardwell's J-450 because of its fast, efficient operation. You will like it because it reduces drilling costs! The advanced engineering in Cardwell's J-450 twin-engine draw works provides you with maximum flexibility and maximum adaptability to barge, trailer, or skid operation.

– And, Cardwell's rigidly exact quality control – the result of more than 30 years' experience – protects your investment, and reduces costly downtime – for years to come. We invite you to "call on Cardwell."

the new **cardwell** MANUFACTURING COMPANY

Box 2001
Wichita, Kansas, U. S. A.



Now—a multi-purpose mud additive—

DU PONT CMC GRADE DM!

Low-cost Grade DM reduces fluid loss, keeps viscosity low —has excellent suspending action

Here's an additive you can use with practically *every* kind of mud. It's Du Pont CMC Grade DM.

Add Grade DM to sea-water muds—low- or high-pH fresh-water muds—gyp-base muds—low- or high-lime muds —oil-emulsion muds. You can count on it for minimum fluid loss, *even with reduced* viscosity in some systems. It has the thermal and bacterial resistance needed in deep wells as well as possessing excellent suspending action. It provides superior emulsifying action in oil- water-emulsion muds. And all of these are yours at rock-bottom cost.

Both inshore and offshore operators report substantial dollars-per-ft. savings—can Grade DM do the same for you? Order this versatile mud additive from:

- your local mud dealer
- Du Pont Explosives Department offices in Dallas, Texas; Los Angeles, Cal.; or Wilmington, Del.
- Macco Corp., Paramount, Cal.
- Baroda & Page, Inc., offices in Corpus Christi, Dallas, Houston, Kansas City, New Orleans, Odessa, Oklahoma City, Tulsa, Wichita.

DU PONT SODIUM CMC

Sodium Carboxymethylcellulose

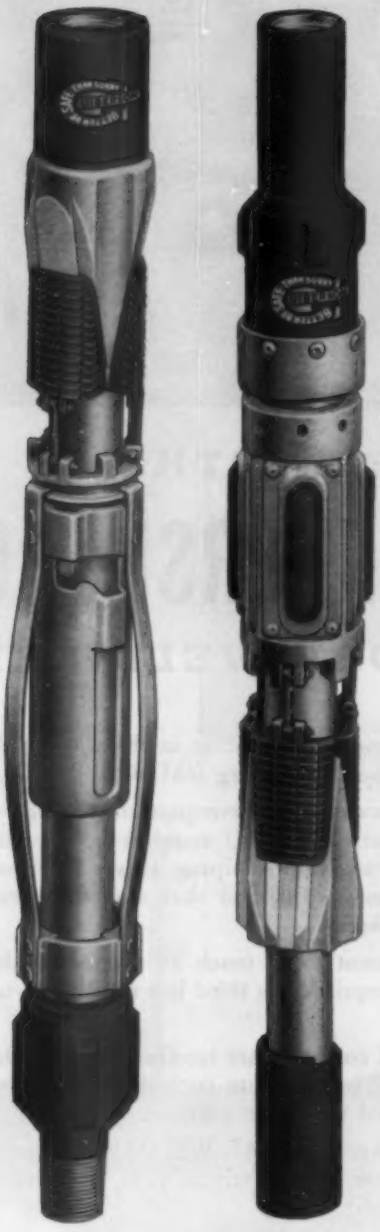
DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING .. *THROUGH CHEMISTRY*

STOP TUBING MOTION *with a*

GUIBERSON TUBING ANCHOR



TYPE AC

TYPE AF

You get three important savings when you support pump and tubing with a Guiberson Tubing Anchor — *save wear* on tubing, on collars and threads, on casing. When string is anchored, you'll have fewer leaks and the pumping operation will yield more fluid with less power. Guiberson gives you two types to choose from.

TYPE AF is a tension tool equipped with friction pads and automatic latch. It holds when tension is applied to string. A safety joint is incorporated in the bottom connection that lets you break loose if junk fouls the latch mechanism.

TYPE AC is equipped with jay-slot and friction springs. It holds when tubing is lowered. When unlatched and pulling, Type AC functions as a tubing catcher.

Both types made in a wide range of casing sizes and weights.

THE

GUIBERSON

CORPORATION

ESTABLISHED 1919
DALLAS, TEXAS
U. S. A.

Sold by
OIL Field Supply Stores
Everywhere

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YOU SAVE 3 WAYS WITH A PARKERSBURG *DAU WELDRIER

In addition to obtaining the most efficient dehydration in the world today, you realize tremendous savings with the Parkersburg DAU WELDRIER.

Your savings begin with the initial low cost of this compact unit, along with savings on equipment and installation. The DAU requires no auxiliary operating equipment such as heaters, separators, piping, valves and costly hookup time. It is completely unitized, piped, and skid mounted—ready to go on stream with but four connections.

Your savings on operating costs amount to as much as several hundred dollars per month because the DAU requires one third less desiccant—uses 80% less fuel gas.

Your savings from the costly effects of corrosion are inestimable. The DAU removes water vapor at the wellhead to eliminate corrosion and hydrate troubles from the gathering system and the entire pipeline.

These three big savings make the Parkersburg DAU WELDRIER your best dehydrator buy today. Get complete details from your Parkersburg Representative.

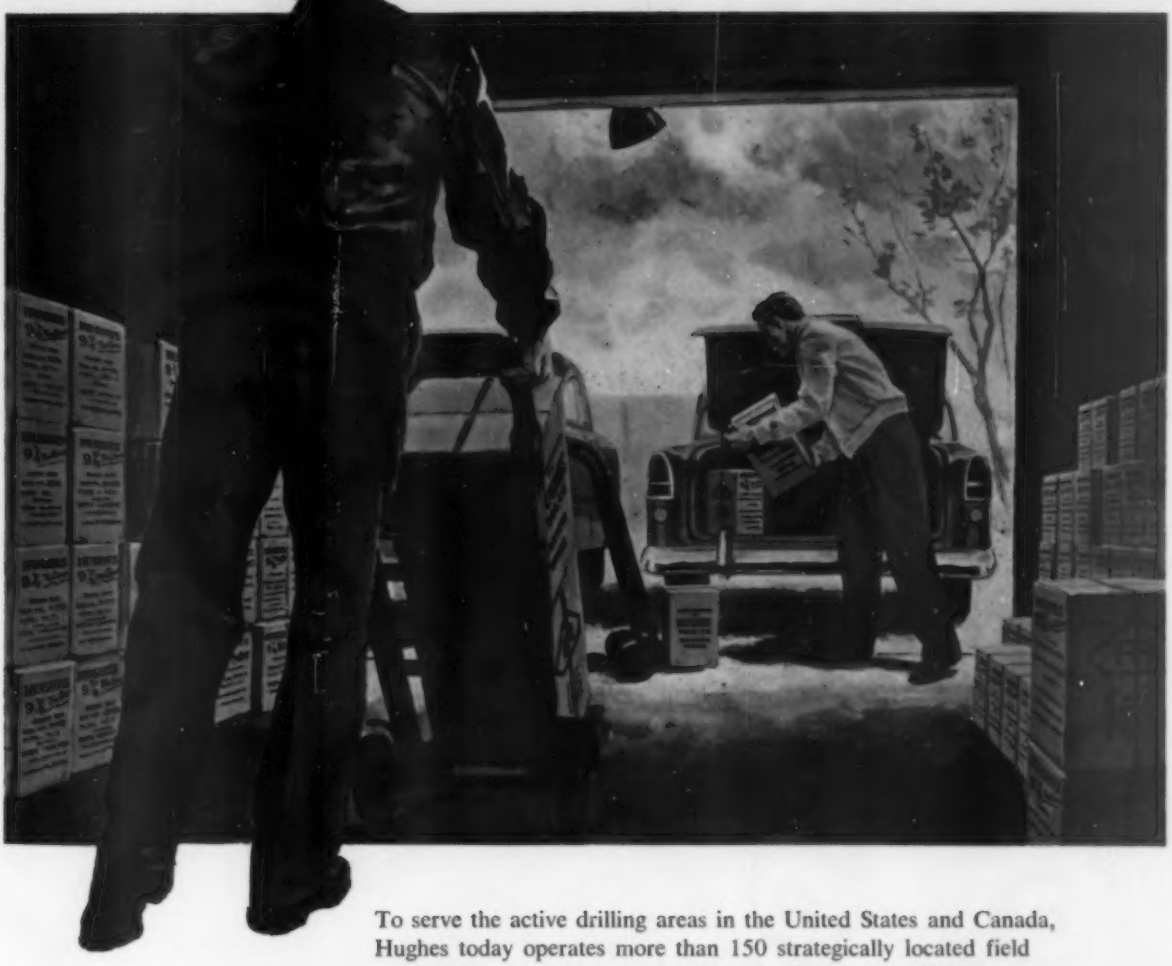
* DYNAMIC ADSORPTION UNIT

Parkersburg
RIG AND REEL COMPANY
DIVISION OF PARKERSBURG : AETNA CORPORATION

3345 WINTHROP AVENUE
FORT WORTH 16, TEXAS

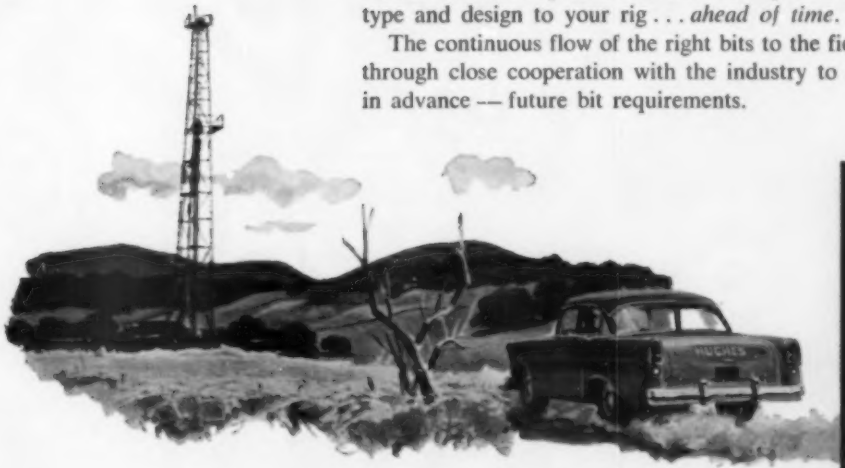
9632

Vital link in the service chain



To serve the active drilling areas in the United States and Canada, Hughes today operates more than 150 strategically located field stockpoints. They represent another vital link in the Hughes service chain set up to assure the delivery of bits of the *right* size, type and design to your rig . . . *ahead of time*.

The continuous flow of the right bits to the field is made possible through close cooperation with the industry to determine — months in advance — future bit requirements.



why we don't trust spot bit runs

We've learned from long experience in developing new bit designs that you can't rely on spot bit runs to tell how a bit will really perform. You can only be sure of *predictable* performance when results have been repeated and repeated. Not only in one field, but under comparable conditions in many different fields.

There are other variables, too. Formations change from location to location and field to field. Weight makes a difference. Rotating speeds, mud characteristics and mud volume and pressure make a difference.

Each year, hundreds of thousands of bit records and dulled bits are analyzed by Hughes engineers in evaluating design and metallurgical changes. This is another *big* reason why the performance of HUGHES rock bits is the *world standard of the industry!*

there's always a standard LUFKIN unit with the right *Combination* of

. . . BEAM CAPACITY

. . . COUNTERBALANCE

. . . PEAK TORQUE

for your well

Lufkin **FOUNDRY & MACHINE COMPANY**

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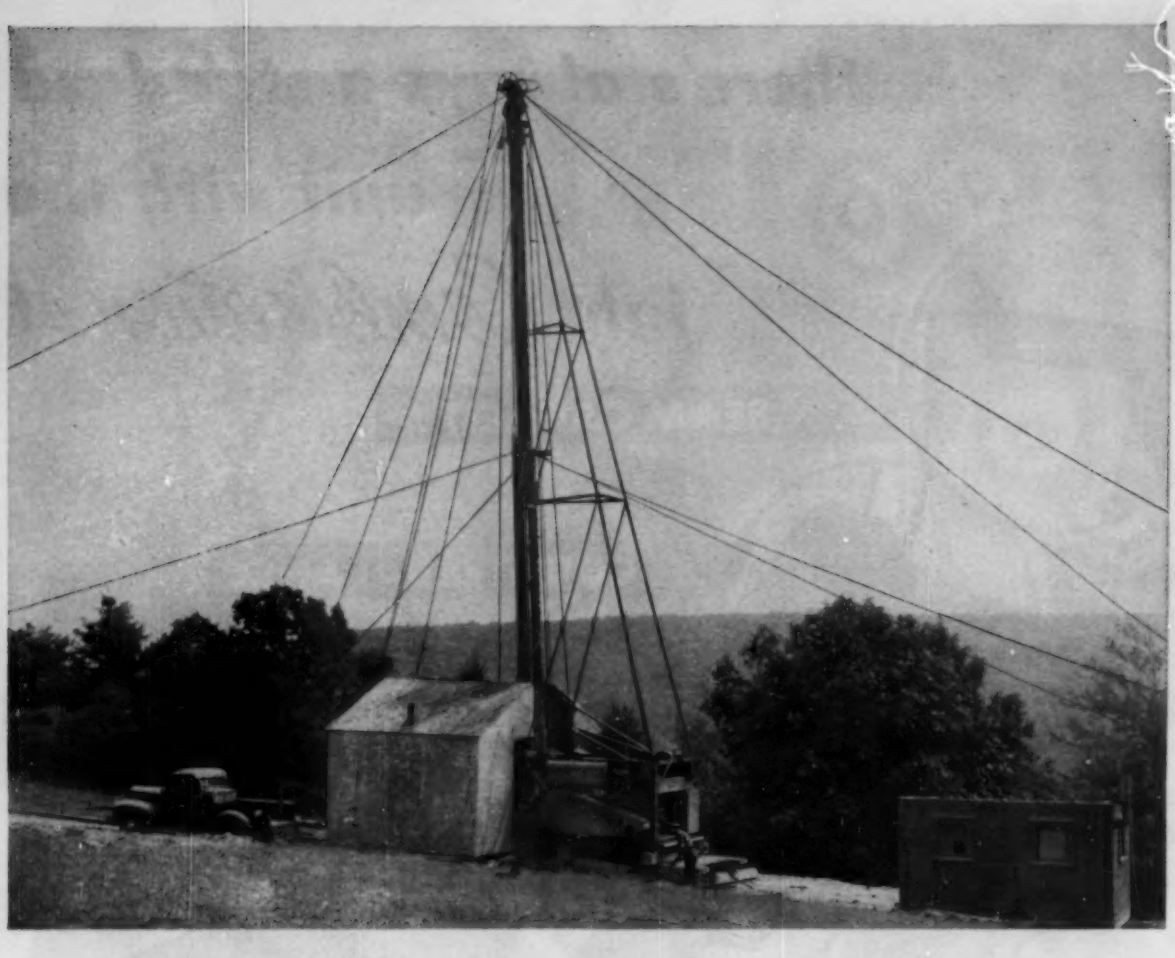

Why BUCYRUS-ERIE Spudders pay off on Secondary Recovery

Bucyrus-Erie spudders offer the speed and mobility you need for fast, profitable secondary recovery operations. These modern rigs assure rapid progress hole after hole, with quick easy moves and reduced costs all down the line.

You can't beat the *speed* with which Bucyrus-Eries put down hole. Snappy spudding action, with shock absorber that can be blocked out for deep drilling, means real drilling speed in any formation. Forward and reverse speeds on all reels and on the catheads provide the accurate, split-second control that diversified operations require. Reels are free-wheeling for lowering. Fast powerful line pulls result in fast trips in handling tools, bailer, casing, or rods in clean-out work.

And when it comes to moves, Bucyrus-Eries really save time. Their telescoping derricks are lowered and raised quickly under power, tubular braces unfold smoothly. Mobile semi-trailers or skid mountings make *moving* easy.

Two popular choices for secondary recovery work are the 60-L and 28-L machines. For complete information on them, see the Bucyrus-Erie spudder distributor in your area or write us direct. 30556

60-L Top-to-bottom drilling to 1,500 ft.;
Servicing to 2,000 ft.;
Swings up to 2,750 lbs. of tools.

28-L Top-to-bottom drilling to 2,500 ft.;
Servicing to 3,000 ft.;
Swings up to 3,700 lbs. of tools.

BUCYRUS ERIE

SOUTH MILWAUKEE, WISCONSIN

FIRST with the FINEST in SPUDDERS

PHOTO COURTESY RICHARDSON & BASS COMPANY

"For the world's deepest hole we use the world's best lighting protection —NEOPRENE!"

Says G.G. (Pinky) Jordan
Toolpusher,
Richardson & Bass
Rig 25

"In drilling our four-and-a-quarter-mile hole near New Orleans," continues Pinky Jordan, "we had to have adequate, troubleproof lighting. It's good safety insurance to have vaporproof light sets protected with neoprene."

When Pinky says "protected," he means it. Resilient neoprene seals on lights and junction boxes are unaffected by sunlight and heat from the lamps . . . give lasting protection against moisture and gas.

And neoprene jacketing on the light cable guards against deterioration from oil, grease, sunlight and heat. *Any* neoprene product can cut your replacement costs through long, trouble-free service. Hose, packings, vibrator screen mounts, drill-pipe protectors and piston rubbers are a few of the applications in which neoprene offers long life and outstanding resistance to deterioration.

FINAL ADJUSTMENT is given a Rig 25 light by driller H. D. (Douglas) Wright. Long-lasting neoprene in this lighting system helped keep lights burning continuously during drilling of the four-and-a-quarter-mile hole. (Photo courtesy Hutchison Manufacturing Company, Houston, Texas.)

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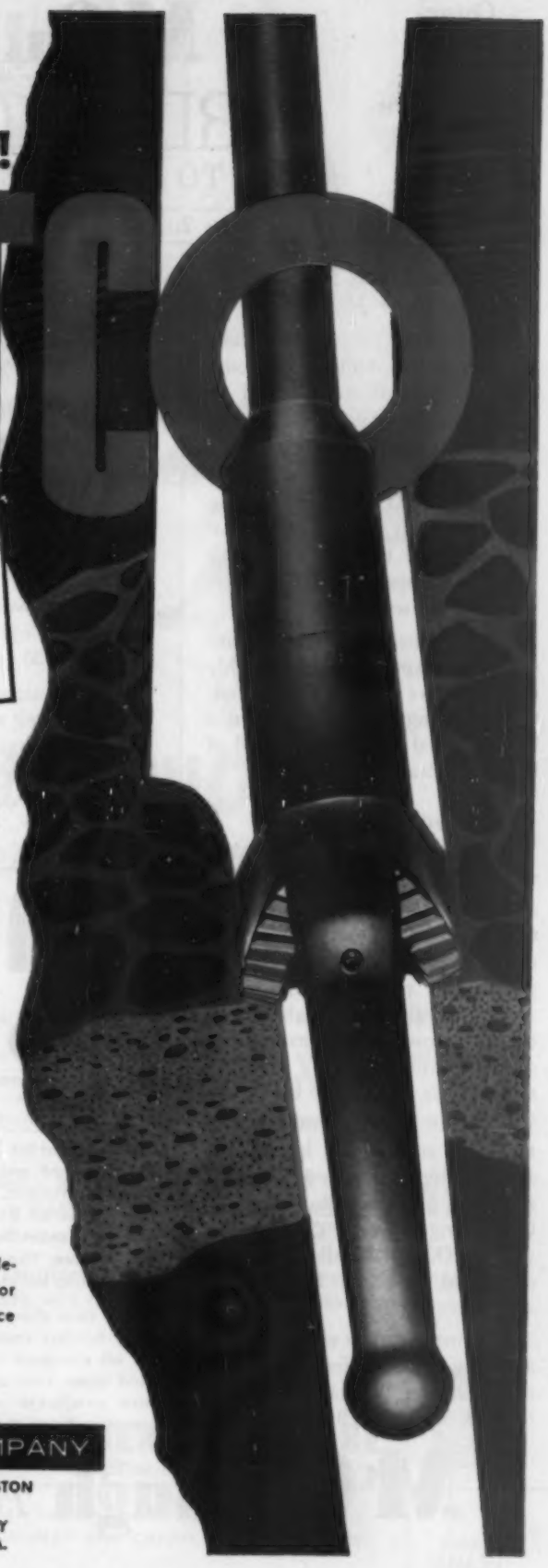

- Here is the best tool to use for reaming whipstock or knuckle joint pilot holes to full gauge. It is also used in opening core holes.
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M-3 Guns Shoot 1268 Holes in Four Hours

Firing an average of 317 bullets per hour in this shallow Oklahoma well is an outstanding record of perforating speed and efficiency.

McCullough 4¼" O.D. M-3 Bullet Guns fired 1268 improved ½" Ogival Bullets in 7" O.D. cemented casing in two intervals from 1040' to 1064' and from 2762' to 2790'. This was a salt water disposal well. Operator was well pleased.

Speed like this can only be accomplished by experienced, thoroughly trained crews and by using simultaneous firing M-3 Bullet Guns – fastest, most efficient method of bullet perforating available.

M-3's Succeed After Two Others Fail

Two other service companies attempted to perforate this Montana well without success. One was unable to accurately locate the collars and perforated the water zone. The other was unable to do the job because the shots were in dry hole and incoming pressure moved their gun up the hole.

Within 1½ hours, McCullough moved in on the job, located the zone to be perforated, fired 32 improved ½" Ogival Bullets in 5½" O.D. casing between 3955' and 3963' with 3½" O.D. M-3 Bullet Guns, tore down and moved off. Results good – operator happy.

This is just one more example of the accuracy of McCullough measurements and of the value of simultaneous firing M-3 Bullet Guns.

Superior Penetration Pays Off ...Fracturing Job Successful

Hard Shooting M-3 Bullet Gun Permits Successful Completion of Sandfrac Job...Penetrates Tough Formation After Other Bullet Gun Failed.

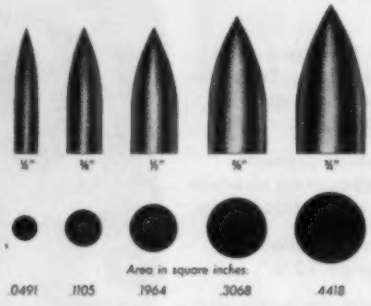
Previously perforated by another service company, the operator was unable to fracture the formation in this Illinois well; pressures up to 4000 psi were reached without results.

McCullough was called to re-perforate the well with 4⅛" O.D. M-3 Bullet Guns firing improved ½" Ogival Bullets. Twenty shots were fired through 5½" 14 lb. J-55 cemented casing in a five foot interval from 2833' to 2838'.

After perforating by McCullough the well "broke down" at 1600 psi and took fracturing material at the rate of 350 gallons of oil and 700 pounds of sand per minute. This well is now flowing – one of the best in the field – and the entire perforating job, including rigging up and tearing down, required only 1½ hours rig time.

The superior firing power of M-3 Bullet Guns; the deep penetrating qualities of improved Ogival Bullets are particularly valuable where tough, tight formations must be fractured for good production.

There are many jobs like this on record, where the superior penetrating power of McCullough M-3 Bullet Guns has successfully completed the job after others failed. Next time, be sure of results – call McCullough first.



Improved McCullough Ogival Bullets are designed for maximum piercing ability. Type and quality of steel, heat treatment, weight, shape, sharpness of point, etc. are all carefully controlled factors in their production. They are the deepest penetrating bullets known.

Bullet sizes shown above are standard. Burrless caps are available to fit all standard sizes. Special sizes and types, such as the 1/16" and 1/8", are available to meet unusual requirements.

Do you want to see how other oil men have benefited by using McCullough M-3 Bullet Guns? Send for your copy of "RESULTS" – field reports of outstanding jobs successfully completed by M-3 Guns.

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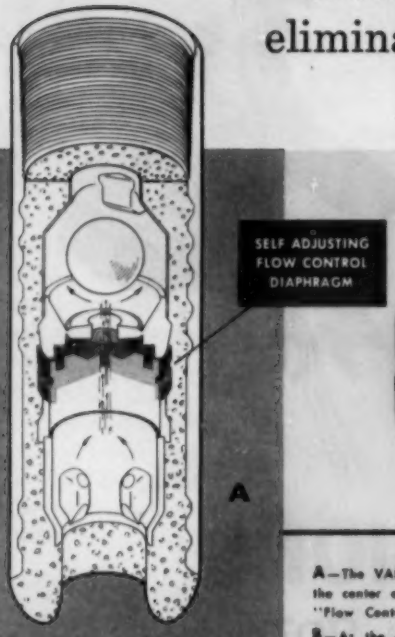
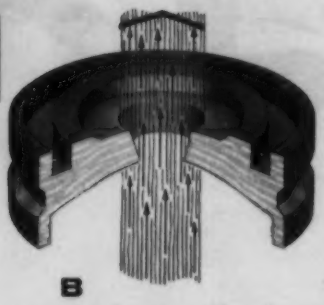
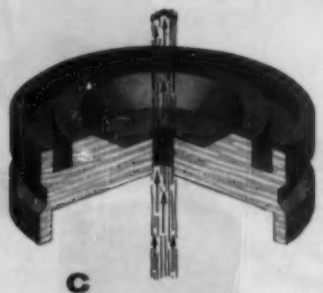
See for yourself...

how the variable valve in FLEXIFLOW Shoes and Collars automatically fills the casing and eliminates destructive pressure surges



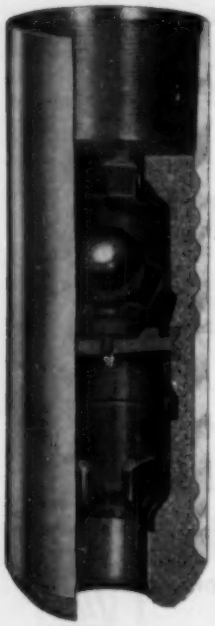




A—The VARIABLE VALVE consists of a small hole in the center of a reinforced synthetic rubber disc called "Flow Control Diaphragm"; see view at left

B—As the casing is lowered, pressure from below is exerted on the diaphragm and causes the hole to open up (see B) and a sufficient volume of fluid enters the casing to prevent a build up of destructive pressure surges

C—As the rate of lowering the casing is lessened (just prior to setting the joint in the slips) differential pressure from below decreases and permits the Flow Control Diaphragm to contract, thus causing the hole to return to its smallest diameter (C). The reduced volume of fluid entering the casing prevents overfill.



Baker
FLEXIFLOW FILL-UP Shoe
Product No. 160

When casing equipped with FLEXIFLOW Shoes or Collars is lowered in the well, increase in pressure from below causes the variable valve to open up wider to relieve pressure from below by permitting a large volume of fluid to enter the casing. When downward movement of the casing is slowed down, pressure from below is reduced and the hole in the diaphragm contracts to restrict the fluid entry and prevent overfilling. This action of the variable valve in opening wider and closing down, synchronizes the rate of fill of the casing with the rate of lowering the casing, *and in so doing provides maximum relief from pressure surges.*

CUTS RUNNING TIME ONE-THIRD — Baker FLEXIFLOW Shoes and Collars can safely reduce casing running time by as much as one-third, because . . . they completely eliminate time-wasting surface filling of casing; and they permit the casing to be run faster due to the automatic "fill" from the bottom that eliminates possible damage to the formation from high-pressure surges.

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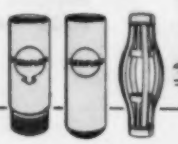


BAKER FLEXIFLOW

P 305.

EXCLUSIVE

WHAT'S AHEAD FOR THE PERMIAN BASIN?

West Texas authority promises that the "heyday" is yet to come — stratigraphic trap-type fields yet to be found; value of secondary recovery not yet at its peak; value of West Texas sour crudes increase; crude outlets to the Gulf Coast provide added impetus

W. D. Thorn *Five-Star Oil Report, Inc., Midland, Texas*

Rotary rigs, like this one running in Midland County, number almost 600 for the Permian Basin.

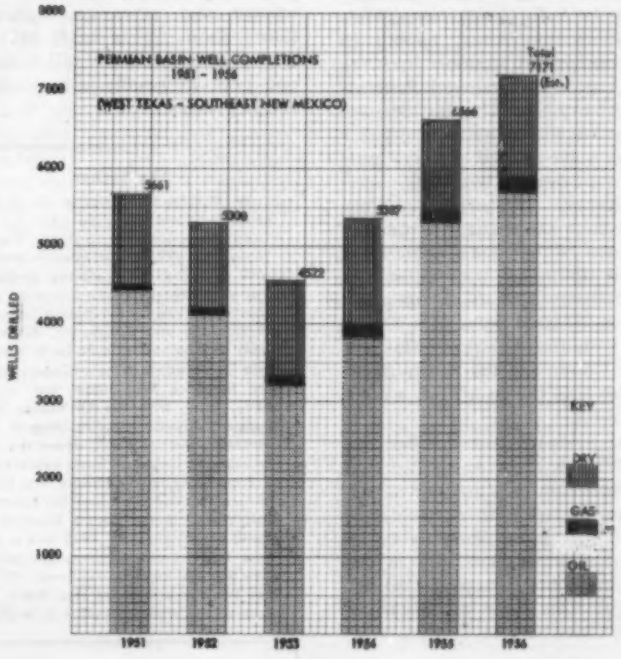
HISTORY of the nation's greatest oil province, the Permian Basin of West Texas and Southeastern New Mexico, is well known to all oil men. Since the days of the first big gushers during the late 1920's in Reagan, Crane, Pecos, Upton, and Winkler counties, the literature of the industry has described in detail the steady but spectacular expansion of both the geographical and geological limits of the area.

In this almost limitless country one mile after another succumbed to the wildcatter's drill. As the same drill penetrated deeper into the earth's surface one geological world after another likewise was found productive of oil and gas. Today the great Permian Basin oil fields, although producing under stringent allowable restrictions, send to market almost 1,500,000 bbl of crude per day — approximately 20 per cent of the total oil production of all fields of the United States.

Basin Now At Its Peak?

Today, some folks say, the Permian Basin is at the peak of its capacity, that its biggest fields already have been found, and that there is no likelihood that it can turn out more major discoveries.

Total well completions in the Permian Basin of West Texas and Southeastern New Mexico since 1951. Data from Railroad Commission of Texas and New Mexico Oil Conservation Commission. Completions for last month of 1956 were estimated based on activity.



San Andres crude flowing to this tank battery in Yoakum County, Texas, provides prosperity even in this year of drouth in West Texas. Notice the poor maize crop in the foreground.

This belief, of course, may be a true one, but the oil men who know the area best are not inclined to believe it. They do not anticipate new fields similar to the Yates or McElroy or Hendrick pools but place their hopes in future structural field discoveries and even more faith in stratigraphic traps.

Basis of the faith of those who believe that the Permian Basin is far from "through" as a source of new oil supplies for the nation is based largely on the theory that the geologist can combine his science with up-to-date well completion and recovery methods to help find and produce oil from formations that in the past have been either overlooked or regarded as non-commercial.

These geologists point to the vast Spraberry formation production that has been developed in southwestern Borden County, emanating in the Jo-Mill Spraberry field. This discovery was made by J. E. (Sam) Jones, Midland drilling contractor, hoping to make a commercial producer from the Spraberry of an abandoned Pennsylvanian reef dry hole. That his idea was a good one is shown by the facts that Jones has since turned down a purchase offer of over $3,000,000.

The Jo-Mill Spraberry play has spread to such an extent that the productive area of the stratigraphic trap-type field embraces the upper and lower Spraberry and the Dean sand, may cover 200,000 acres. The Texas Railroad Commission already has combined the Canon and the Arthur Spraberry fields into the Jo-Mill as a common reservoir.

Further evidence that the Permian Basin still holds a promising future is seen in the action of a number of major companies who have established division offices in Midland to supervise their activities not only in the Permian Basin but in adjacent oil districts as well. This group includes Humble, Shell, Cities Service, Gulf, Sunray, Mid-Continent, Superior, and Sinclair. Several other major companies have granted their Midland district offices much greater freedom in accepting or rejecting leases and drilling deals than is customary for most district offices.

Matching the efforts of major companies to find and develop new oil and gas reserves in the Permian Basin are dozens of strong independent companies and scores of independent operators. Combined activity of the major companies and the independents has made office and housing space scarce throughout the Basin and affords ready employment for all types of personnel.

1956 Record

The record to date for the year 1956 indicates that the push of activity in the Basin is nowhere near an end. Late statistics may show that during the year the area has produced slightly more oil than has been found. This indicates that wildcat and extension drilling has found about 550,000,000 bbl of reserves — that's a lot of oil! If found in one pool it would be equivalent to another Yates field.

The Author

W. D. (Bill) Thorn began his oil field experience walking pipe lines for The Texas Pipe Line Company in Mexia, Texas, in 1923, subsequently worked with Crusader Oil Company at Cotton Valley in North Louisiana and with Southern Crude Oil Purchasing Company at Eldorado and Smackover, Arkansas, went with Southern Crude (later merged into Stanolind) to Winkler County where the Hendrick field boom was in full sway. Later, with Lee O. White, independent operator now residing in Fort Stockton, went to Pecos where the pair engaged in Delaware Basin exploration.

From 1935 to 1942 Thorn was editor of C. D. Lockwood's Texas Oil Report at Fort Worth; joined the Ira Rinehart Oil News organization in 1949 and a year later became one of the organizers of Five Star Oil Reports, Inc. Since 1951 he has been in charge of Five Star's Permian Basin publishing office at Midland.

New Pipe Line Outlets

Substantiating proof of the belief that the Permian Basin will continue to be a major U. S. crude source is seen in the plans underway for the construction of a big-inch crude oil trunk pipe line from West Texas to the Gulf Coast.

A group of major companies are reported as being very interested in the joint construction of the 250,000 to 300,000 bbl a day line.

Present trunk pipe line capacity out of the Permian Basin is 1,946,900 bbl daily. The proposed new line would raise this to around 2,250,000 bbl a day. In order to make money the big trunk lines have to handle almost their rated capacity, hence it appears obvious that if a new 250,000 bbl line is built, Permian Basin's production will be increased considerably from its present 1,500,000 bbl daily average.

Primary market for Permian Basin crude is the Texas Gulf Coast. This accounts for the fact that the trunk lines now in operation (with a rated capacity of 1,946,000 bbl daily) seldom ship more than 1,600,000 bbl. The unused space is in lines going to Midwestern areas, rather than to the Gulf Coast where the big refineries of Humble, Gulf, Shell, Texas, Magnolia, Atlantic, and others have an almost insatiable demand for crude and where there also are facilities to ship crude to other major refining centers of the United States.

Inland Refining Center

Another large and increasing Permian Basin crude market is the El Paso inland refining center. Pasotex Pipe Line Company, subsidiary of Standard of California, presently ships via pipe line about 55,000 bbl of oil daily through a looped 8-in. system between Wink and El Paso. This system is being replaced with a new 20-in. carrier that will soon deliver 70,000 bbl a day to El Paso refineries of Standard, The Texas Company, and El Paso Natural. Refining capacities of those plants are being enlarged and there is some speculation that El Paso Natural may build a completely new unit to replace its present Brickland refinery.

Humble, some months ago, announced its plans to lay 94 miles of 18-in. line from its Ector station southward through Crane County extending southeast to its mainline station at Kemper in Reagan County. Pipe for this line was arriving via barge in Houston early in November and was to be doped and wrapped in Houston before being shipped to West Texas. Actual construction is to start in December with completion expected around March 1. This line is engineered to handle 70,000 bbl daily of sour crude

Natural gasoline plants like this typify growth of a new industry in West Texas. Although much of the Permian crude is piped to Gulf Coast refineries, much "end use" products are being manufactured from area plants.

Dual producing wells abound in the Permian Basin where multi-pay prospects are good in almost every section. This Amerada Petroleum Corporation well is in the Dora Roberts field in Howard County, Texas.

and will enable Humble to boost substantially its present rate of oil shipments out of West Texas to the Gulf Coast.

Need for the new Humble line arose primarily from the phenomenal Queen sand development in the Means field and adjacent areas during the past two years. This Queen development is often cited by those who place great faith in the Permian Basin's future as a good example of things to come.

Another boost in oil shipments to the coast will be afforded after January 1, 1957, by Rancho Pipe Line. This big 24-in. carrier now pushes about 232,000 bbl daily to the Houston area and will increase its flow 25,000 bbl a day.

Natural Gas Products

Aside from the impressive crude oil trunk line expansion programs started in the Basin this year, the position of natural gas liquid products assumes new importance. Last fall Magnolia started shipping natural gas products through a trunk line system extending to Beaumont. Gulf has work underway converting one of its old 10-in. trunk lines to the coast for use as a products carrier.

Highlighting the stature of natural gas and its products in the Basin during the year was the announcement by General Tire and Rubber Company, Odessa Natural Gasoline Corporation, and the El Paso Natural Gas Company of plans to build a synthetic rubber complex at Odessa. Work is already underway. Cost of the three principal plants being built to produce the rubber is close to $40,000,000. The installation will be the first of its type to be built in the interior of Texas, away from the big synthetic rubber and petrochemical plants that line the Texas Gulf Coast.

Field Development

Major field developments in the Basin this year have largely centered on gas and gas-distillate wells and fields. In fact the emergence of the Permian Basin during the past years as a major source and processing center of both associated and non-associated natural gas is noted by the area's economists as marking one of the greatest forward steps made by the oil and gas business during the Basin's history.

Singling out the most important new discoveries in the Basin since last January, is a task comparable to finding a needle in a haystack. In Railroad Commission District 8 (the Midland district) alone there had been over 100 new discoveries through the month of October. The proved area of the Basin today is so large that a new discovery of much importance to one group of operators is given little attention by others.

Lease Play

Some plays, however, command respect and attention of all operators. One of these was a purchase last June by Stanolind Oil & Gas Company of a University of Texas lease drilling block Tract No. 116. This 3800-acre drilling block called for the drilling of a 16,000-ft Ellenburger wildcat, and was awarded for cash bid of $4,250,000. Not only did this set a high record for the University's lease auctions, but pushed the Pecos County area into the forefront of areas of interest among Permian Basin operators. Drilling is now underway on the deep test with a half interest held by Gulf Oil Corporation. Gulf made a fifty-fifty swap with Stanolind on this block and one in Crockett County which Gulf bought at the same sale.

Permian Basin Crude Production by Months, by Districts, for 1956

	Dist 8 (Midland)	Dist 7-C (San Angelo)	S. E. New Mexico
Jan	31,953,685	5,614,023	7,346,767
Feb	30,123,044	5,368,104	6,745,900
Mar	32,556,034	5,715,656	7,371,496
Apr	30,944,230	5,365,440	6,880,697
May	31,432,215	5,465,451	7,028,942
June	30,191,221	5,230,595	6,862,514
July	32,399,888	5,459,274	7,157,032
Aug	33,540,961	5,615,000 (Estimated)	7,183,026
Sept	31,500,000 (Estimated)	5,475,000 (Estimated)	7,026,680
Oct	32,500,000 (Estimated)	5,475,000 (Estimated)	(Not yet completed)
Nov	31,500,000 (Estimated)	5,350,000 (Estimated)	(Not yet completed)
Dec	32,000,000 (Estimated)	5,475,000 (Estimated)	(Not yet completed)

Other plays in the Basin that have been watched or participated in by a majority of operators include the pre-Permian oil and gas-distillates strikes in Winkler County, extensive spread of Queen sand production in numerous Central Platform areas, Pennsylvanian wet gas and oil production in Midland and Martin counties, a great burst of activity in Irion County on the southeastern edge of the Basin, pre-Permian exploration in Southeastern New Mexico, deep and shallow wildcatting in the Delaware Basin, continued successful exploration for Pennsylvanian pays on the east side of the Permian Basin in Stonewall, Nolan, and adjacent counties, and a persistent search for new Permian oil fields in a trend through Garza, Lynn, and Lubbock counties.

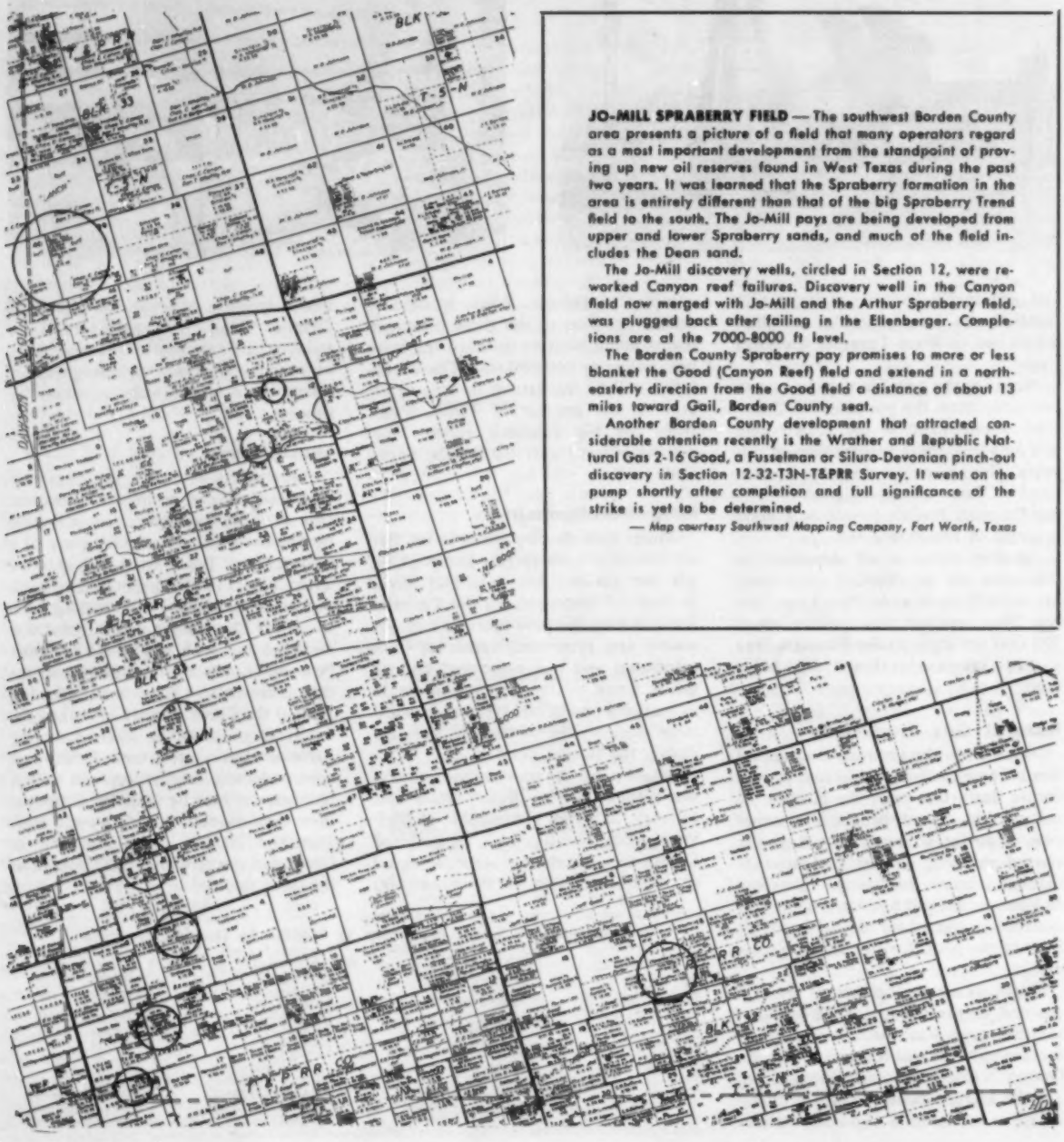
Wildcats Widespread

It can be seen that the search for new fields in the Permian Basin during 1956 has spread through every county and to every known formation with some successes in each instances. It is worth noting, however, that one formation, the Cambrian, which blazed with great promise along the Eastern shelf two years ago, has not yielded a single barrel of new oil to wildcatters since the discoveries at Bronte, White Flat, Dora, and EA. Wildcatters are still hoping, however, and one or more of half a dozen tests now underway could turn up a new Cambrian field before the year is over.

Puckett Bonanza

History of events leading up to the $4,250,000 University lease block purchase by Stanolind in Pecos County is long, capped by opening of the Puckett (Ellenburger) field by Phillips Petroleum Company 1 Glenna from pay topped at 13,605 ft.

The Phillips strike came in 1952, or about 20 years after the company first began geological and geophysical reconnaissance work in the area. Its No.



JO-MILL SPRABERRY FIELD — The southwest Borden County area presents a picture of a field that many operators regard as a most important development from the standpoint of proving up new oil reserves found in West Texas during the past two years. It was learned that the Spraberry formation in the area is entirely different than that of the big Spraberry Trend field to the south. The Jo-Mill pays are being developed from upper and lower Spraberry sands, and much of the field includes the Dean sand.

The Jo-Mill discovery wells, circled in Section 12, were reworked Canyon reef failures. Discovery well in the Canyon field now merged with Jo-Mill and the Arthur Spraberry field, was plugged back after failing in the Ellenberger. Completions are at the 7000-8000 ft level.

The Borden County Spraberry pay promises to more or less blanket the Good (Canyon Reef) field and extend in a northeasterly direction from the Good field a distance of about 13 miles toward Gail, Borden County seat.

Another Borden County development that attracted considerable attention recently is the Wrather and Republic Natural Gas 2-16 Good, a Fusselman or Silura-Devonian pinch-out discovery in Section 12-32-T3N-T&PRR Survey. It went on the pump shortly after completion and full significance of the strike is yet to be determined.

— Map courtesy Southwest Mapping Company, Fort Worth, Texas

1 Ada Price, first deep test in the area, was abandoned as a dry hole in 1945 at a total depth of 15,279 ft, on a location three miles east of the discovery gasser.

Phillips developed its prospect with rapidity and also arranged for a pipe line outlet for the gas through a new line built by Permian Basin Pipe Line Company extending northward from the field about 30 miles southeast of Fort Stockton to the Tex Harvey area in Midland County, a distance of about 100 miles. From Tex Harvey, the Permian Basin line went on northwestward to a connection in southern Yoakum County with other trunk gas line systems going north and west.

The Ellenburger gas in the Puckett field was found to have a very high carbon dioxide content which in combination with the high pressures resulted in severe corrosion problems to both the producing wells and to the processing plant built in the field by Permian Basin Pipe Line Company.

To offset the negative qualities of the Ellenburger gas came the discovery and development of Devonian formation gas in the field. This gas not only has been found in great volume, but also contains little of the carbon dioxide content and corrosive qualities associated with the Ellenburger production.

Proved area of the Puckett field from Devonian and/or Ellenburger is now approximately 10,000 acres. On the north edge of the development thus far one good show of oil has been found at the Gulf Oil Corporation 1 Robbins "A" from 10,129-177 ft, with a flow of oil registered on a drillstem test. Neither of two tests now being drilled as Gulf's No. 2 and 3 Robbins "A" to the west nor the Hammonds 1 Robbins, a mile to the north found any Pennsylvanian oil.

The Hammonds well flowed oil from a Simpson age lime on a test at 10,875-11,010 ft to point up additional possibilities for the Puckett field.

Output from the field has been limited by processing capacity of the Permian Basin company's processing plant of 25,000,000 cu ft daily. Capacity of the plant is being enlarged, and a decision of the Texas Railroad Commission announced early in November, ordered the plant to take gas from all producers in the field on a ratable take basis. Atlantic Refining Company, who acquired ownership of a producing well on the northeast side of the field through its purchase of Houston Oil Company had initiated action before the Commission to force the plant to accept gas on a ratable take basis from all producers. The Commission order will permit Atlantic, Gulf, and George S. Hammonds and Phillips, presently the only operators in the area, to share the outlet.

Deep exploration has brought new oil prospects for the bald prairie of Southeastern New Mexico. This rig, owned by Lowe Drilling Company, is operating in Lea County. Drillers are now increasing exploration into Pennsylvanian, Siluro-Devonian and Ordovician formations.

Field Boundaries

Puckett field appears to be defined to the east and west but looks wide open to the north and northwest along a trend toward the high-priced Stanolind University lease block. No exploration has been attempted south and southeast of the Phillips discovery well, however. Should the field extend north-northwestward for six miles, Gulf Oil Corporation would be in a very fortunate position as it holds leases on approximately 18,000 acres of land in that trend. Should it extend farther northwest, then the University of Texas would reap tremendous benefits through its ownership of a solid block of some 100,000 acres of land.

Puckett field, as of the middle of November, had 19 producing wells — 16 belonging to Phillips. Gulf had two tests drilling and Phillips had one underway.

Phillips' Big Gassers

Puckett field is now considered the largest dry gas reservoir yet found in West Texas. Attention was focused on the field in October when Phillips reported potentials on two big gassers, one for 370,000,000 cu ft daily and another, its 2-D Puckett, for 570,000,000 cu ft per day. These large potentials drew comment from all quarters of the natural gas industry and also brought a retesting request on the 2-D Puckett from the Texas Railroad Commission.

Many petroleum engineers believe that a gas well absolute open-flow potential vanishes into infinity after it reaches around 100,000,000 cu ft a day. Others believe their slide rule calculations are infallible. In this case the Railroad Commission asked Phillips to submit a new potential of 77,000,000 cu ft per day or re-test the well under Railroad Commission supervis-

Desert country is being exploited, not in Arabia, but near Monahans, Texas. Trucks being pulled through the sand are those of a Shell Oil Company seismic crew.

ion. The company has elected to re-test the well.

Neutral observers shrug off the difference of opinion as to the actual potential of the well as merely another incident in the innumerable arguments which the Railroad Commission has had to decide between oil and gas producers since the inception of proration formulas. Out of the difference of opinion may come a gas well potential formula to which all parties will agree.

Aside from its immediate economic value, the Puckett field discovery is regarded by some as a major geologic marker. It falls within the Sheffield Channel, one of the many sub-geological provinces incorporated in the general term Permian Basin. Other subprovinces include the Central Basin Platform, the Midland Basin, the Concho Platform, the Eastern Shelf, the Horseshoe Atoll, the Matador Arch, the Plainview Basin, the Northwestern Shelf, and the Delaware Basin.

Geologists in this group believe that major companies had complete confidence in their geophysical interpretations of the area. These companies bid millions of dollars for the Pecos County drilling block which Stanolind bought with its high bid of $4,250,000.

If this is substantiated with the drill it is hoped that the geophysical interpretations will enable explorers to make a successful "back door" approach to the pre-Permian beds of the great Delaware Basin which the Sheffield Channel connects with the Midland Basin. Deep exploration in the Delaware Basin has been stymied by the inability of geophysicists to rely on their shooting data, and any clue to a better method of interpretation would be regarded as invaluable to those who continue to look forward to the Delaware Basin as a potential source of major oil and gas reserves. Deep exploration to date in the province has resulted in the discovery of Pennsylvanian and Devonian wet gas production, principally at Bell Lake in Southeastern New Mexico, at the El Paso Natural Gas and Stanolind 1-X Welch Unit in southern Eddy County, at the Toyah (Devonian) field in Reeves County, and the Shell 1-17-A University in Southwestern Winkler County. The Shell wildcat was drilling in the Devonian formation at our publication deadline and its results in that formation are being checked with much interest. Geologically the well is located in the transition zone between the Central Platform on the east and the Delaware Basin to the west. Its outcome will have great influence on future deep exploration along this transitional trend.

Shell's 1-17-A University wildcat was coring at 17,290 ft in Devonian lime, chert and shale. It had logged an oil show in the Wolfcamp and also had a heavy gas-distillate flow from Pennsylvanian at 14,110 ft. On a structural comparison basis the well is about 8000 ft "low" to another Winkler County wildcat 12 miles to the northeast, one of the major pre-Permian strikes of the year on the Central Platform. This wildcat is the Richardson Oils, Inc. (Richardson & Bass interest) No. 1 Stanolind "B" Hill & Mitchell. It topped Devonian at 9510 ft, on an elevation of 2768 ft, lower subsea than any Devonian production previously established in Winkler County, but established a 400-ft thick Devonian gas-distillate section, tested oil in the Montoya and gas-distillate in the Simpson. It was completed as an oil well from the Montoya to rate as the first oil producer in the county from that formation, although several months later it was reworked on account of a high gas-oil ratio.

Since its completion last March, the multi-pay field has been developed steadily with indications that the Devonian will make oil also on the northeast flank of present development. Ohio Oil currently is drilling ahead after flowing oil on a Devonian test on the same flank.

The rich sequence of pays found by the Richardson wildcat, which was a deep test in the old shallow Halley field, typifies the pre-Permian exploration in old shallow areas of Winkler County during the past year. Costs of the wells are high but engineers estimate that a 400-ft thick Devonian gas-distillate pay in this area is worth about $10,000,000, if the gas is sold at about 13 cents per thousand.

Emperor Field Activity

In the Emperor (Ellenburger and Devonian) field, opened in October, 1954, by the Barnes & Lyman 1 Kerr, the Devonian, Fusselman, and Ellenburger formations have since been extended to prove up several thousand acres. A major westward extension this year was the Stanolind-Westbrook-Thompson No. 3 T-89-B Hendrick. This hole was dual-completed for gas potential of 74,000,000 cu ft daily from Devonian at 9110-60 ft and 113,000,000 cu ft a day from the Ellenburger at 11,340-400 ft. It is the second pre-Permian test and the first pre-Permian producer drilled on the old Hendrick Ranch block on which Roy Westbrook and Stanley Thompson, Fort Worth operators, drilled one of the Permian Basin's sensational discoveries of the year 1926.

Augmenting interest as a new source of gas and distillate, progress of the well was watched with unusual interest by owners of the 1,800,000 shares of outstanding common stock of the Westbrook-Thompson Holding Corporation. Value of the stock rose from about $2 to $5 a share on the strength of the well.

Newest development in the Emperor area saw Humble Oil & Refining Company 1 Brown & Altman Gas Unit No. 1 flow 45 bbl of 37 deg oil in two hours on a drillstem test of the Wichita-Albany (Permian) formation. This is the first well in the area to find oil in that zone. The Humble test is a diagonal northeast offset to the Barnes-Lyman No. 1 Kerr deep discovery. Its performance in the new Wichita-Albany zone follows the pattern established in many Permian Basin fields during the past year, i.e., the "incidental" or "accidental" discovery of good pays in zones other than primary objectives.

Discovery of these new zones in so many spots is a direct reflection of the effort used today by most companies to assure that every geological and engineering aid will be used to avoid passing up something worthwhile.

Seven miles north of the deep Emperor field the Standard Oil Company of Texas scored with pre-Permian pays in its No. 1 Lovett. Three miles east of that new area The Superior Oil Company has just completed its No. 1-A Walton for a new Ellenburger producer and was testing the higher Devonian formation to indicate a dual-pay discovery.

In addition to the very successful pre-Permian wells drilled in the old shallow areas of Winkler County was a Devonian discovery by Humble at its 1 Waddell Brothers & Company, 12 miles northeast of Kermit well, flowed 404 bbl of oil per day from 9186-9208 ft to open a new field five miles west of the Wheeler Ellenburger and Devonian field which straddles the Winkler-Ector county-line. The Humble discovery is not close to any old shallow field, is about midway between the Wheeler and the South Keystone pools.

Consistently throughout 1956 the bulk of drilling in the Permian Basin, both fields and exploratory, has occurred along the well established trends of Upton, Midland, Crane, Ward, Ector, Winkler, Andrews, Gaines counties in Texas, and Lea County in New Mexico. This drilling has found numerous new Pennsylvanian and Devonian fields in northern Lea, a new oil field from Pennsylvanian in southern Roosevelt County, New Mexico, at Magnolia Petroleum Company 1 Jacobs-Federal, Section 18-8s-35e, four miles southwest of Milnesand. It produced 218 bbl of oil in 24 hours through 10/64-in. choke from perforations at 9202-10 ft to set

up a new producing area on the most northerly outskirts of Southeastern New Mexico's vast producing territory.

Irion County Boom

Far to the southeast of the new Magnolia producer in New Mexico, a distance of over 200 miles, lies Irion County, Texas, on the southeastern edge of the Permian Basin. During 1956 this county has taken the role previously played by many other West Texas counties in past years, that of changing from the wildcatter's graveyard into a land of promise.

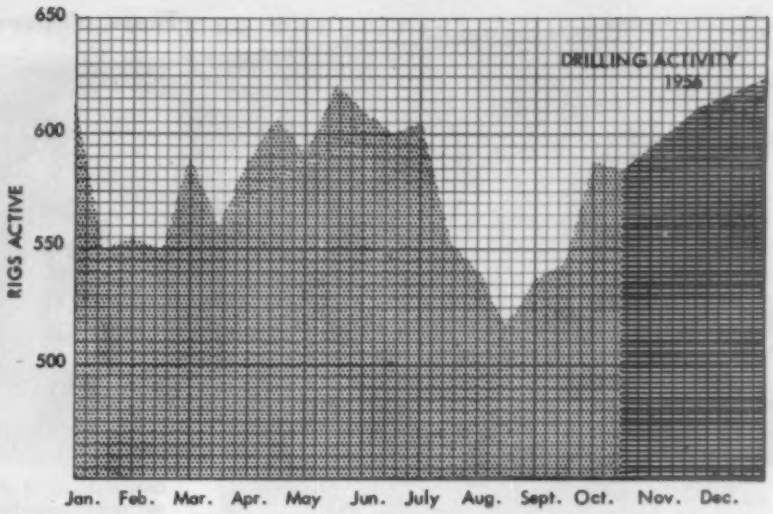
Irion County got off to a good start late in 1955 with discoveries in Clearfork and Glorieta pays by Sinclair at the Ketchum Mountain and Mertzon fields. Early in 1956 the British-American 1 Atlantic-Noelke stirred the industry with a flow of oil from the Strawn reef lime to open the Sixty Seven field. Some prospectors envisaged another Hulldale or maybe something even bigger. The promise did not materalize in subsequent development in the area but it did turn up some shallow 1100-ft San Angelo wells flowing around 100 bbl a day, natural.

Coincident with deep and shallow discoveries was a lease expiration situation that called for quick action with the result that so far in 1956 a total of 64 new holes have been dug. Of these, 21 have either opened new fields or furnished substantial extensions to new areas. An even dozen wells were completed as field producers and the remaining 31 were dry holes.

Despite the high rate of success registered in Irion County there is as yet no indication that any of the Permian or Pennsylvanian pools now being developed will be of major field classification. The big heat is off the lease expirations and further exploration, keyed to structures or traps now known to exist, may enable the geologists to find better fields than now in hand. Formations have been found very erratic. Prevalent belief in major company circles is that the only overall profitable horizon so far found in the Irion County play is the shallow San Andres-San Angelo section.

Andrews County Find

Probably the most publicized well of the year in the Basin was the W. E. Bakke No. 1 Grady, four miles southeast of the city of Andrews, in Andrews County. It was dual completed from Ellenburger pay topped at 12,304 ft and Devonian topped at 10,500 ft, making 1309 bbl of oil per day from the Devonian through ¼-in. choke and 1022 bbl of oil per day through ½-in. choke from Ellenburger. It had tested a good oil show in the Clearfork at 6938 ft, flowed oil from Wichita-Albany at 7740 ft, flowed oil from Wolfcamp at 8575 ft, tested a good show of oil in the Penn at 8980 ft in addition to the deeper pays. The area now is being rapidly developed as the six pays found by Bakke offer a rich target to shoot for. Lease holders in the area think they might find the upper pays rather erratic but look for a substantial Devonian reservoir and a good Ellenburger accummulation.



Drilling activity in the Permian Basin for 1956. Data courtesy Reed Roller Bit Company, Houston. Activity for last two months estimated based on comparable increase in final months of last year.

The Bakke well was more or less sensational even for Andrews County where 75 or more rotary drilling rigs have been busy everyday of the year looking for established field pays or new ones from the Yates and Queen on down to the Ellenburger.

Southeastern New Mexico

An area of great future promise for the Southeastern New Mexico portion of the Basin is seen in western Lea and eastern Eddy counties, along the southward slope of the Carlsbad Shelf, where the upper beds belong to the Delaware group of formations. Many geologists have long believed that an exploration campaign stretching southward from the Carlsbad Shelf would furnish a successful key to the location of oil traps far out in the Delaware Basin.

Among the deep wildcats now showing the way are the Stanolind 1 Greenwood Unit, Section 27-18s-31e, which has drillstem tested oil and gas shows in upper and lower Pennsylvanian at 9850 ft and 10,850 ft, respectively. At the lower depth it flowed 15 bbl of distillate per hour from Atoka sand. The Shell 1 Querecho Unit, six miles east of the 1 Greenwood, flowed 35 to 40 bbl of oil on drillstem test of a Penn lime at 11,569-686 ft. About 15 miles northeast of the 1 Querecho the Phillips 6 Leamex, in Section 23-17s-33e completed flowing 264 bbl of 37-deg oil plus 6 bbl water from Pennsylvanian pay through perforations at 11,328-364 ft.

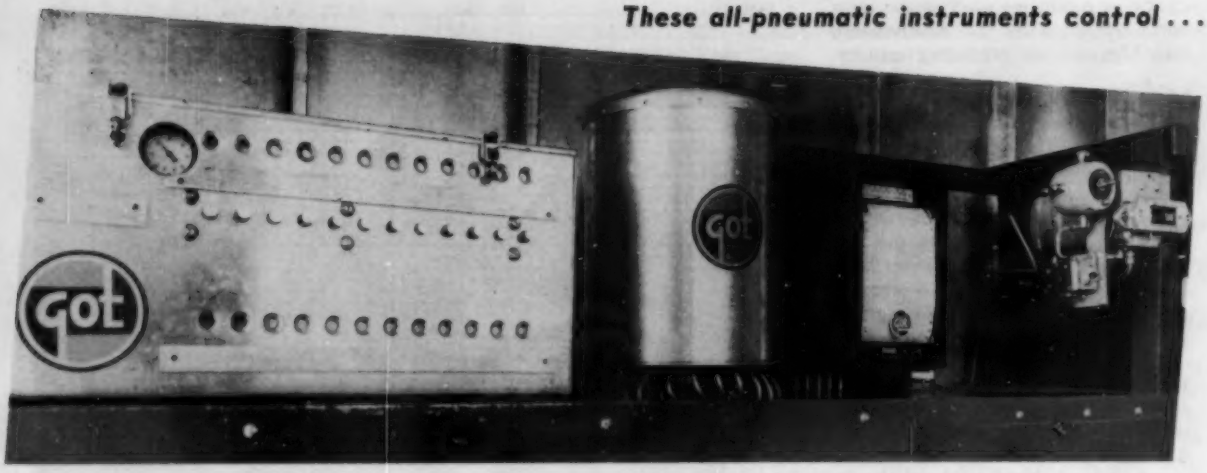
The Phillips discovery was drilled to a total depth of 16,842 ft in pre-Cambrian to establish a new depth record for New Mexico. Phillips had picked a Devonian top at 15,110 ft and Simpson shale top at 16,470 ft, with first granite wash at 16,725 ft. It found slight gas shows in the Devonian.

Permian Prospects Promising

Wells like these, located at the north end of the Delaware Basin, along with Shell's deep Pennsylvanian wet-gasser on the east edge of the Basin in Winkler County, and the Pecos County play generated at the southeastern limits of the Basin by the Puckett area discoveries, indicate that while the approach to deeper reserves in the Delaware Basin has been a long and costly one, the area of it regarded as an unknown quantity is gradually being shrunk smaller and smaller. Result is, that as economic conditions warrant, the vast Basin will offer a promising site for future exploration for many years.

Year-end reports will show that the Permian Basin has set many records in production of oil and gas, number of wells drilled and completed, feet of hole drilled, etc., during 1956. General opinion of the average oil man of the area, whether independent or major-company, is that newer drilling and completion techniques now in use, plus a practical and scientific application of the principles of subsurface geology — directed at finding stratigraphic type oil fields instead of chiefly structures — will keep the Basin at or near its present high level of operations for many years to come. ★ ★ ★

These all-pneumatic instruments control . . .



Only a supply of pilot gas is required to operate these instruments that control production, testing and sampling of 12 wells. Left to right the instruments are: Production programmer, well testing programmer, strip chart recorder and pneumatic integrator that converts orifice meter differential into Mcf.

Operating Costs Cut on Non-Electrified Leases in West Texas by . . .

New Auto-Pneumatic Lease Programming System

An all-pneumatic system of instrumentation automatically operates 12-well separator stations without electricity in Fullerton-Clearfork field. Monterey Oil Company, unit operator, is reducing tank batteries from 141 to 10

Donald M. Taylor
Gulf Coast Editor

ONE of the biggest booms in the oil industry is shaping up in West Texas—and surprisingly enough it is *not* centered around a wildcat drilling rig. Yet this boom like all others has its origin firmly rooted in money.

In an economy where the price of everything except *chewing gum* and *oil* has risen, operators are hard pressed to produce wells profitably. This is especially true in West Texas where pipe line cutbacks have dwindled the income of many fields while labor and operating costs remain constant.

In ever increasing numbers operators in this region are turning to AUTOMATION as a solution to the problem; and dozens of leases are being converted to instruments. But until now, this new trend has been limited to fields where electrical power is available, because automation and electricity go hand in hand.

Recently Garrett Oil Tools, Inc., developed an all-pneumatic system of instrumentation that makes fully automatic operation possible without electricity provided there is a source of pilot gas.

The first installation of the new system was made in the Fullerton-Clearfork unit in Andrews County. This West Texas field, operated by the Monterey Oil Company, now has two 12-well production units completely controlled and regularly tested by the new pneumatic instruments. Production from all 24 of the wells is scheduled by instruments, and oil production from field separators is automatically measured and recorded, and at specified intervals the individual wells are stop-cock tested.

The savings. Originally the unitized area of 594 wells had 141 tank batteries of 3 to 4 tanks each, but when the automation program now in progress is complete the field will have only 10 tank batteries of 6 to 8 tanks each. All of the wells will be controlled. *Electro-pneumatic systems will be used where electricity is available in the field, but in the other areas, all-pneumatic instrumentation will be used.*

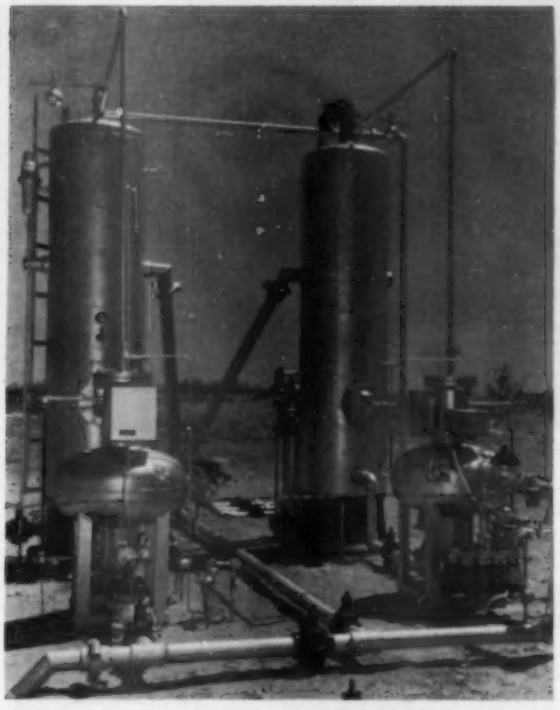
The many small tank batteries are being replaced by field separator and measuring stations, and oil is being piped to the large centrally located batteries where it is heat-treated, automatically stored, manually measured and pumped to the pipe line.

What the Pneumatic Field Station Does

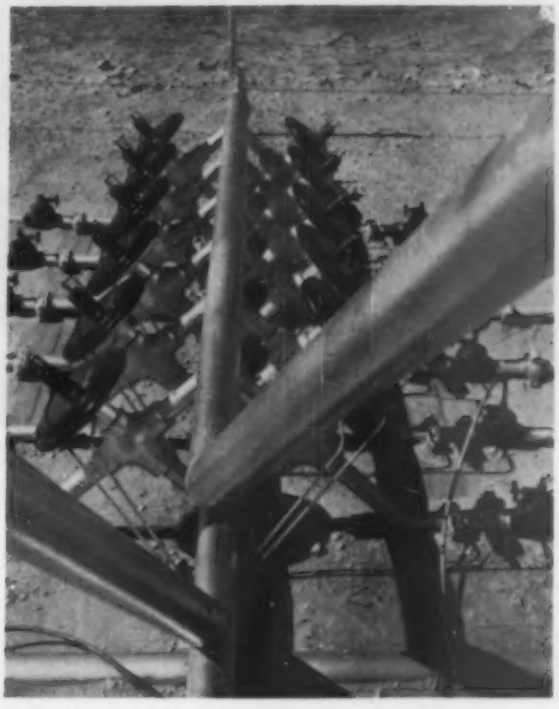
Each of the two pneumatically operated field separator stations serve 12 wells. The gathering lines converge into two headers: One is a production header piped directly into a production separator; the other is a test header piped into a test separator.

Three-way, three-position pneumatic valves control each of the 12 wells flowing into the station. The valves can shut the flow line in, direct flow into either the production or the test header. Because the field is unitized, production from individual wells need not be measured except during tests.

separators, metering vessels, sampler and these three-position valves on 12 flow lines.



Replacing several tank batteries, these two separators, metering vessels and sampler (at extreme right) handle all of the oil and gas production from 12 West Texas wells. Production separator and metering tank are at left, test separator, meter and sampler at right.



Stop-cock production and tests of 12 wells are controlled by these three-way, three-position valves. When instrument gas pressure is applied to one side of the diaphragm, the valve opens the flow line into the production header at left; gas on the other side of the diaphragm opens the flow line into the test header. When pressure is bled from both sides of diaphragm, the valve stop-cocks the flow line.

Normally, when the wells are on production they flow into the production header and separator. The gas from the separator is metered, piped into the field gathering system, and transported to a nearby gasoline plant.

Oil from the production separator is measured by a one-barrel, blow-case metering vessel that automatically dumps the oil into the gathering line. Each time it dumps, it records a pip on a strip chart recorder on the control panel. This gives a cumulative record of total oil production from the field station.

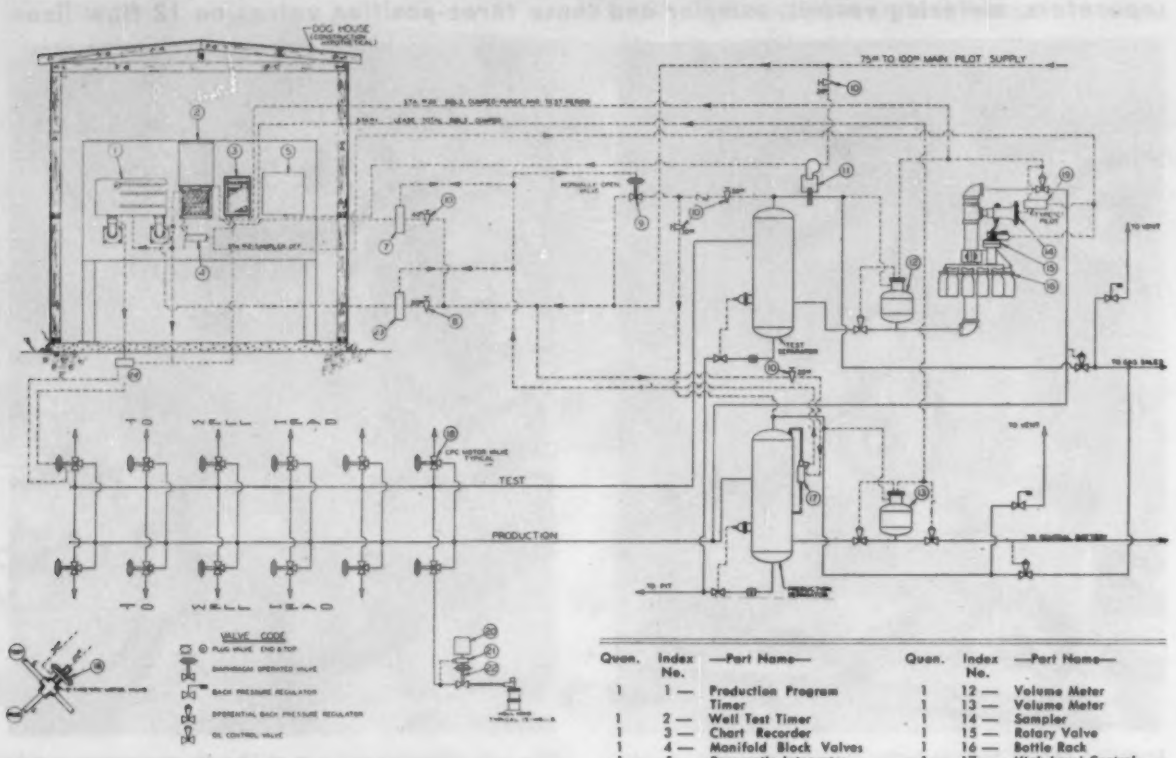
Production programming. All 12 wells flowing into each station are controlled by the production programmer as to each well's "off-on" cycle. This function is usually referred to as "stop-cocking" and is normally associated with high gas-oil ratio well production. This instrument is designed to control all wells in the manifold simultaneously and independently as to the "off-on" or stop-cocking cycle. This is accomplished by the instrument signal to the three-way, three-position valve through which each well flows into the manifold. This signal positions the manifold valve either to the closed or to the open position. The test programmer controls and positions the manifold valve to the test header.

The heart of the production programmer is a 12 wheel timing drum that is pneumatically step positioned in 15 minute increments and controlled by a spring wound 24-hour rotation clock. Each well can be individually programmed within a 24-hour period as to the "off-on" cycle in 15 minute increments.

Test programmer. Once every week each of the wells connected into the station is tested. This operation is controlled by a test programmer that actuates one of three-way, three-position valves to divert flow from the production header into the test header. During this test period, all flow from the well being tested goes into a test separator. The test programmer controls through the production programmer such that each test is started with the well in the shut-in position. This function is normally required by various state regulatory bodies for determining production allowables. Gas from the top of the separator is measured and recorded in **Mcf on a continuous time chart,** and the oil from the bottom of the separator is measured and sampled. After measurement, the oil is diverted into the production separator where it combines with, and is measured with, the total stream from the lease.

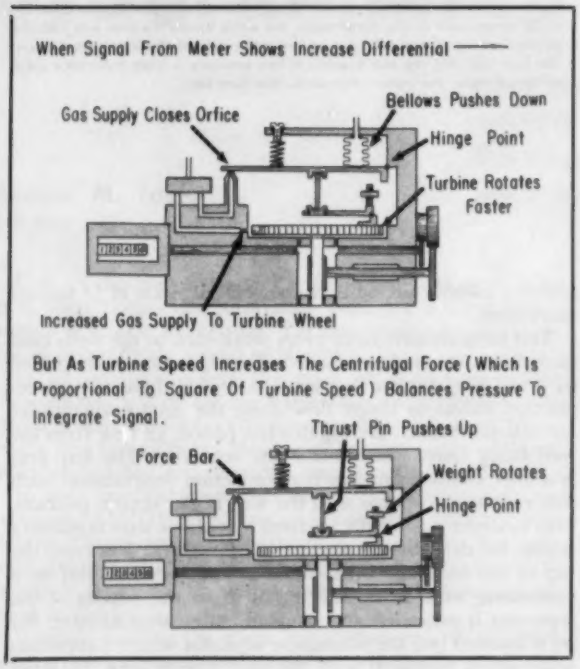
The test metering vessel has a sampling device that takes a minute quantity of oil from each of the one-barrel batches. However, this sampler is inoperative during the first hour of the test. This permits a complete purge of the metering vessel before sampling begins. As each new test begins, the rotary valve attached to the rack that holds the sample bottle indexes one position to bring a new bottle into test position.

Gas is recorded in Mcf during test. Gas from the test separator flows through an orifice meter run, and the signal from



Quan.	Index No.	—Part Name—	Quan.	Index No.	—Part Name—
1	1 —	Production Program Timer	1	12 —	Volume Meter
			1	13 —	Volume Meter
1	2 —	Well Test Timer	1	14 —	Sampler
1	3 —	Chart Recorder	1	15 —	Rotary Valve
1	4 —	Manifold Block Valves	1	16 —	Bottle Rack
1	5 —	Pneumatic Integrator	1	17 —	High Level Control
1	6 —	Special Manifold for Pneu. Inter-Connections	12	18 —	2" CPC Motor Valve
			1	19 —	Type 'C' Shut-in Pilot
1	7 —	CR Control	12	20 —	Pilot
1	8 —	Regulator	12	21 —	CR Control (Low Press. Shut-in)
1	9 —	Miniature Valve			
5	10 —	Regulator	12	22 —	Motor Valve (Normally Closed)
1	11 —	DP Cell			

Schematic diagram of the pneumatic automatic well control installation. One of the remarkable features of this system, aside from the fact that all instruments and controls are operated by pilot gas, is that the functions of all instruments and controllers are ON-OFF rather than throttling. Even the gas from the test separator is recorded in Mcf units by pips on the strip chart. Note that all oil production is measured through the production metering vessel — even the oil from the test metering vessel.

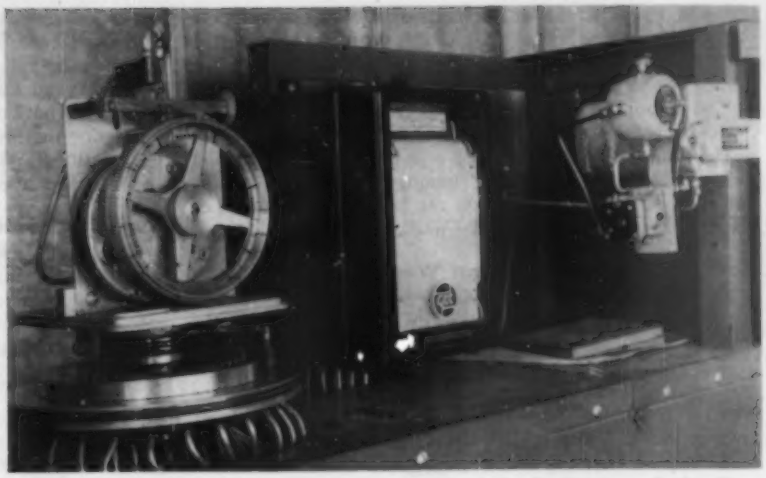

When Signal From Meter Shows Increase Differential
Gas Supply Closes Orfice
Bellows Pushes Down
Hinge Point
Turbine Rotates Faster
Increased Gas Supply To Turbine Wheel
But As Turbine Speed Increases The Centrifugal Force (Which Is Proportional To Square Of Turbine Speed) Balances Pressure To Integrate Signal.
Thrust Pin Pushes Up
Force Bar
Weight Rotates
Hinge Point

How the pneumatic integrator works. This Foxboro instrument utilizes the physical law that the centrifugal force is proportionate to the square of the circumferential speed to integrate orifice differential. An increase in differential signal from the instrument will push force bar down shutting bleed-orifice gas nozzle. This puts more gas across the small turbine and increases the speed until the rotating weight lifts the thrust pin, raising the force bar off the nozzle bleed-orifice. When the two forces are balanced, the turbine's rotations are proportionate to the volume of gas passing through the orifice meter run. It takes about 1 cfm to operate the turbine.

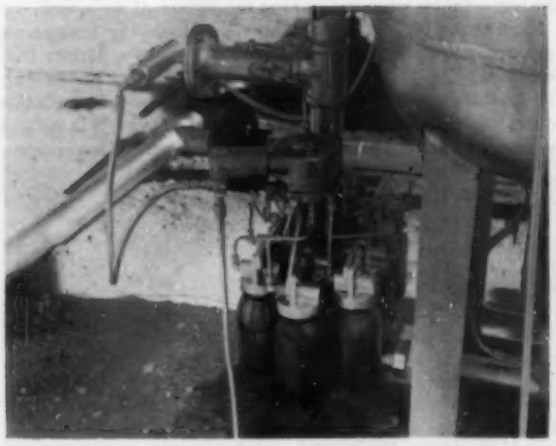
the manometer (representing inches of differential) is fed into a pneumatic integrator in the control room that converts differential into cubic feet of flow. This reading is accurate to only plus or minus 5 per cent because static pressure is set into the instrument as a constant rather than computed as a variable. Of course, the back pressure on the separator is controlled and there is little variation in this pressure.

Chart recorder. Records of the test data as well as total production are recorded on a strip chart. An operations type recorder is used. The positions of the pens show simply whether or not a well is on production or shut in. As each of the metering vessels dumps, a pneumatic signal causes the appropriate pen on the recorder to make a pip on the chart. To count barrels of oil—either of total production or of test production and/or, test gas—the numbers of pips on the chart are totaled.

Flow line control at the wellhead. In addition to the choke on each well, there is a flow controller that limits the pressure in the flow line. The controller valve has a soft-seated tapered plug that maintains a downstream pressure of about 125 psi. This plug is positioned by a pneumatic signal from a pressure reducing pilot. When the well first comes on stream, the valve smoothes out pressure surges, and when the well stabilizes,

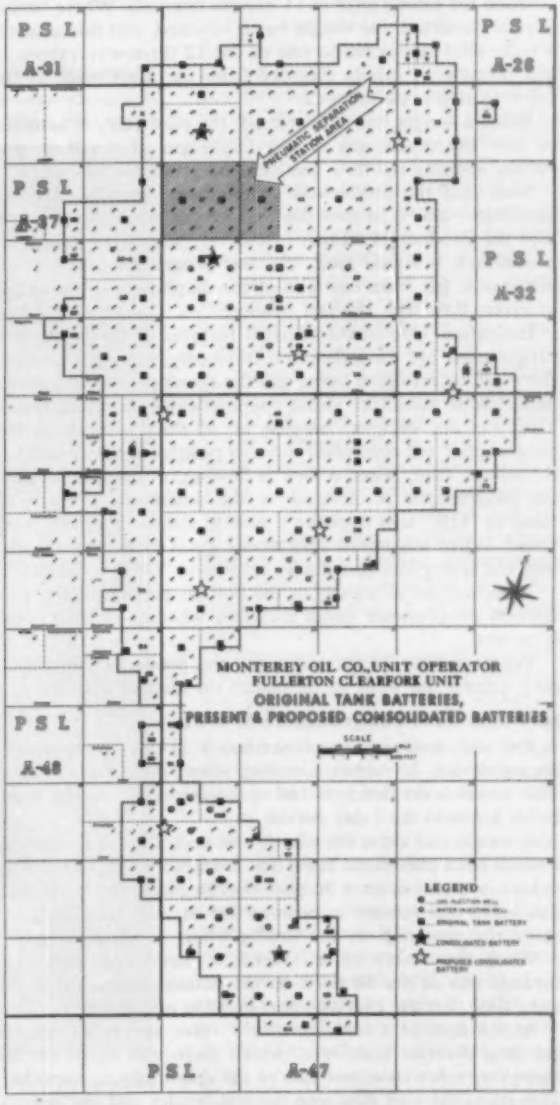


Close up of the test programmer, strip chart and integrator. A 31-day clock spring in the test programmer rotates the timing wheel every seven days. Each time the weight bar that rides over the wheel encounters a metal timing clip, it indexes a rotary valve one position on the bottom plate which has 50 pneumatic outlets. Such a signal can actuate pilot relays which, in turn, divert instrument gas from one side of the diaphragm of a three-position valve to the other to put a well on test. The strip chart shows which wells are on production, which well is on test and records the gas and oil produced by the well on test as well as the total oil production of the lease.



Automatic sampler. During the first hour of the test, the sampler is held inoperative. After that, it takes a minute quantity from each one-barrel batch the blow-case metering vessel dumps.

Test meter and sampler. Bob Crossman of Garrett Oil Tools explains its workings to J. F. Dinda, Creole Petroleum Company engineer. After the oil is dumped from the metering vessel it is routed through the production separator so the entire oil production is measured at all times.



The payoff. The black squares represent 141 tank batteries of 3 to 4 tanks each that are being replaced by 10 tank batteries of 6 to 8 tanks each.

the valve opens all the way, allowing the choke to have full control of the flow. Installation of this flow line control permitted the use of low pressure flow lines which were in place originally and permits wells to be stop-cocked from the separation station.

Other controls at the field separator and test station. The production separator is equipped with high level controls and there are relief valves on lines running to the central battery and gas sales. All of the controls are fail-safe, and in case of instrument gas failure, all of the wells are shut in.

How the Pneumatic System Works

How the production programmer works. This instrument is composed of a multiple station drum programmer and a spring-wound timing device similar to a gas-lift surface controller. The latter has a 31-day spring-wound clock drive that delivers a pneumatic pulse every 15 minutes. This pulse actuates a ratchet drive that indexes the 12-well drum programmer one space. Thus, the drum makes one full rotation every 24 hours by indexing 96 times.

Weight bars ride each of the 12 circular discs which are notched for timing clips in 15 minute intervals. Where timing clips are inserted, the weight bar is elevated, and this actuates a relay pilot connected to one of the 12 three-way valves. In this position, it bleeds pressure from the diaphragm of the valve to stop-cock the well.

When a weight bar is depressed, the pilot relay is actuated to flow instrument gas to the diaphragm of the three-way valves, opening the flow line into the production header.

Note that the production programmer controls only two functions—one is to shut the well in; the other to open flow into the production header. However, when the well is on production, a signal from the *test programmer* can divert instrument gas from one side of the diaphragm to the other, to direct flow into the test header.

Indicators. One of the unusual features of the production programmer are the indicators. Obviously, without electricity there can be no signal lights and the developers of this equipment had to substitute visual pneumatically operated signals. This was not difficult, because all of the functions of the programmer are controlled through positive pressure with no throttling. Thus, when a well is flowing, a small cylinder in the programmer is elevated by the pneumatic pressure to raise an "ON" sign opposite a hole in the front of the panel board. When pneumatic instrument gas is bled from the system, the spring-loaded cylinder returns to "OFF" position.

A second set of signals in the bottom portion of the production programmer panel indicates whether or not a well is on test.

Toggle valves. Toggle valves on the production programmer, permit the wells to be placed on manual control.

How the Test Programmer Works

The well testing programmer has a 31-day spring-wound timing device. It rotates a timing wheel once each 7 days. This wheel is divided into 168 spaces representing the number of hours in the 7-day period.

A weight bar rides the wheel, and each time it is elevated it sends out a pneumatic pulse that indexes a single-port rotary valve one position on a 50-port bottom plate. Once indexed, this valve will remain in position for at least one hour, because the next clip on the timing wheel is one hour away.

When the rotary valve indexes it flows instrument gas through one of the 50 ports on the bottom plate, and at the same time, lets the previous port bleed to atmosphere.

At the start of a test, the rotary valve admits instrument gas to a diverter pilot relay which shifts the signal on the three-way valve from one side of the diaphragm to the other. This starts the well flow into the test header and test separator. A check valve arrangement in this system prevents the sampling mechanism from getting motive gas until the rotary valve indexes one more position. This allows the well to purge one hour under test prior to taking samples.

When the rotary valve indexes the second time, the test continues and sampling starts. This operation will continue indefinitely until the next timing clip appears under the weight bar riding the timing wheel to index the rotary valve to the next position. When this happens, the sampling ceases, and the next clip stops the test.

How the Pneumatic Integrator Works

The gas flow from the top of the test separator is measured by a conventional orifice meter, however, the test procedure would be considerably complicated by the tasks of planimetering and changing instrument charts. For this reason, the signal from the orifice meter is integrated and the gas flow is recorded in Mcf.

The integrator that does this job is actually simple. It balances the differential pressure signal received from the manometer against the centrifugal force produced by a small gas turbine. In so doing, it extracts the square root function in flow measurement, as the centrifugal force produced by a rotating wheel is proportionate to the square of the speed.

Here is the way it works. The signal from the instrument (representing inches of differential) depresses a flapper that closes off a by-pass on a controlled gas bleed. This in turn diverts the gas stream against a bladed turbine which rotates generating centrifugal force in a weight. Through a hinged mechanism, the centrifugal force will raise the flapper when it overcomes or balances the differential force.

The static pressure and temperature are set into the instrument as constants, but the accuracy is sufficient for well tests at any rate.

Advantage of the Pneumatic System

The primary advantage of the pneumatic system is that it permits lease programming to be carried out by instruments in locales where electricity is not available. This very fact may mean that many fields until now considered too marginal to produce may be counted as reserves since it will enable operators to produce them profitably.

Acknowledgment

The author wishes to express appreciation for the help provided by the following: Don S. Wallace, of Monterey Oil Company, unit operator of the Fullerton-Clearfork unit; Robert N. Crossman, Don E. Whittenberg, of Garrett Oil Tools, Inc.

AIME Names Dr. A. B. Kinzel 1958 President

Following a meeting of the board of directors in New York, the American Institute of Mining, Metallurgical, and Petroleum Engineers has announced the election of Dr. Augustus B. Kinzel, of New York, as president for one year beginning February, 1958. Dr. Kinzel is vice president of Union Carbide and Carbon Corporation in charge of research.

Carl E. Reistle, Jr., of Houston, vice president of Humble Oil & Refining Company, is currently president of the Institute. Grover J. Holt, of Ishpeming, Michigan, general manager of the ore mining department of the Cleveland-Cliffs Iron Company, now president-elect, will become president in 1957, taking office February 26 at the annual meeting to be held in New Orleans.

Others, besides Dr. Kinzel, elected to take office in 1958, are:

Vice presidents, to serve three years — Edmund C. Babson, Calgary, Alberta, Manager, Canadian division, Union Oil Company of California, and Roger V. Pierce, Salt Lake City, consulting mining engineer.

SOUTHEASTERN NEW MEXICO'S

Rich Oil and Gas Potential

There's lots of "growing room" on the western side of the Permian Basin, with most oil production now coming from rocks of Permian Age; accelerated drilling and geophysical activity indicates increased importance of Devonian, Silurian and Ordovician formations

Randall F. Montgomery
Geologist, New Mexico Oil Conservation Commission
Hobbs, New Mexico

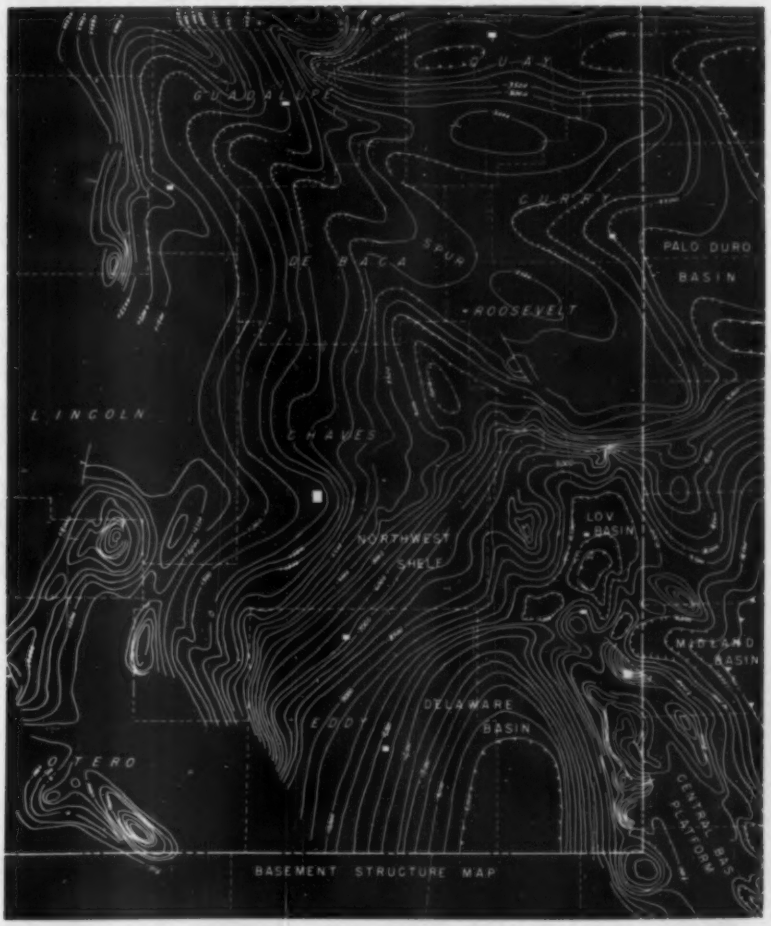


FIG. 1. **Basement Structure map** of Southeastern New Mexico. The area is composed of Lea, Eddy, Chaves, and Roosevelt counties, and is within the geologic province known as the Permian Basin, Central Basin Platform, and the Northwestern Shelf.

UNDER much of Southeastern New Mexico there is a thick section of potential oil and gas bearing sediments, and with the extensive exploration work that is now being carried on, numerous new fields will be discovered. This area, composed of Lea, Eddy, Chaves, and Roosevelt counties, is consistently one of the most active areas in both drilling rig and geophysical activity in the nation.

Most of the existing production in this area comes from rocks of the Permian age, although geologically older formations are becoming more important. The oil and gas production region is within the geologic province known as the Permian Basin, Central Basin Platform, and the Northwestern Shelf.

HISTORY

First recorded oil discovery in Southeastern New Mexico was in the Dayton pool in 1909, although the first commercial well was completed by Flynn, Welch, and Yates in 1923. The latter well is located in Section 31, Township 18 South, Range 28 East, and had an initial potential of 1,500,000 cu ft of gas per day and some oil. This was the beginning of the development of the Artesia-Vacuum Trend.

Next important step was the extension of the shallow "sand belt" production northward from Texas. The Texas Company completed the No. 1 Rhodes in Section 22, Township 26 South, Range 37 East, for an initial potential of 300 bbl of oil per day on November 1, 1927. This was the beginning of the development of the Monument-Jal Trend. Other important discovery dates include the Maljamar pool on July 16, 1926; Eaves, June 1, 1928; Wilson; August, 1928, and other shallow pools such as Lynch, Cooper-Jal, Vacuum, and Eunice-Monument, all in the early part of 1929.

Discovery of prime importance during these early years was the Midwest Refining Company's (now Stanolind Oil and Gas Company) No. 1 State in Section 9, Township 19 South, Range 38 East, completed on November 8, 1928, with an initial potential of 700 bbl of oil per day at a depth of 4220 ft as the discovery well in the Hobbs field. At this time Hobbs consisted of two buildings, a school house, and a county store. Fourteen months later Humble Oil and Refining Company completed the second well in the field for an initial potential of 7275 bbl of oil per day. Six months later, in 1930, the population of Hobbs exceeded 10,000 people. The lack of market and general

This article was originally presented before the Interstate Oil Compact Commission, December 3, 1955, in Santa Fe, New Mexico, under the title "The Oil and Gas Producing Zones of Southeastern New Mexico." Data were revised and updated by the author to include latest statistics.

business conditions of the time caused the development of Southeastern New Mexico to be delayed, and only 1500 people had remained in Hobbs by late 1931. By 1933 drilling again became active and remained so until 1937, the reason being improved economic conditions and the development of completion techniques; namely, acid treatment.

First pre-San Andres well was completed by R. Olsen in April, 1944, as a gas well from the Glorieta formation. The first pre-San Andres oil production was obtained a few months later in the Drinkard field, and soon after many of the 11 pays on the Eunice High were developed causing a very marked economic impact on the area. Another important development was the completion of the first pre-Permian well drilled by the Continental Oil Company in the Cass pool for Pennsylvanian production in December, 1944.

First deep production in the Northwestern Shelf area was not completed until May 6, 1948, in the Crossroads field. This was the beginning of the rapid discovery and development of the Devonian and Wolfcamp fields of the Northwestern Shelf such as Denton, Knowles, and Saunders. These discoveries have caused the recent rapid growth of the industry in Southeastern New Mexico.

Southeastern New Mexico now has 9149 producing oil wells. The total value of the oil and gas in Southeastern New Mexico will exceed ¼ billion dollars in 1956.

MAJOR STRUCTURAL FEATURES

Delaware Basin

The Delaware Basin is enclosed by Permian reefs and bounded on the north by the Artesia-Vacuum Trend and on the east by the Central Basin Platform. The formations of the Delaware Basin, and the back-reef facies wedge into the transgressing reef. The sediments of the Delaware Basin consist of thick sandstones, black shales, black limestones, anhydrite, halite, and potash. The basin measures some 100 miles east and west and 150 miles north and south. The basin is known to have in excess of 19,000 ft of sediments. The Capitan reef that borders the Delaware Basin reaches 1300 ft in vertical development in the Guadalupe Mountains according to Newell, et al, measures 1½ to 3½ miles in width. Adams and Frenzel have reported the reef to reach as much as 30 miles in width along the northern margins of the basin.

The Delaware Basin was warped first in Late Pennsylvanian time, and accentuated during the Permian. The Wolfcamp sediments were the first basin type rocks deposited in the Delaware Basin.

Although the Delaware Basin contains numerous thick source beds and favorable reservoir beds, only two-tenths of one per cent of the state's total production has been obtained from the Delaware Basin.

Artesia-Vacuum Trend

The Artesia-Vacuum Trend forms the northern border of the Delaware Basin. In this area the environment during the Permian period was vastly different from that of the Delaware Basin. This is an area consisting of organic reef facies, and back-reef facies consisting of sandstones, dolomites, anhydrites, and red shales.

In this area, oil is obtained from successively younger formations southward toward the Delaware Basin. Porosity and permeability development are the controlling factors in the accumulations of this area. This is attributed to the migration of the reef seaward and the accompanying migration of favorable reservoir beds. The farther east on this trend the better the recovery from the reservoir, the Vacuum field having the highest recovery, and the recovery decreasing westward to the Artesia field. Most of the reservoirs of the Artesia-Vacuum Trend are Guadalupe in age. The pre-San Andres has not been extensively developed in this area. The Wolfcamp is productive in one well in the Empire Wolfcamp field. The Pennsylvanian has five scattered gas wells, and the Devonian is productive in one well on the Maljamar structure. The Paddock is producing oil from three wells also on the Maljamar structure.

Of the top 10 fields in the state as to accumulative production: The Artesia Vacuum Trend has three; Vacuum the third largest field in the state, Grayburg-Jackson seventh, and Maljamar eighth.

With fields such as the Vacuum, which has produced over 75,000,000 bbl of oil, the Artesia-Vacuum Trend has produced 20 per cent of the state's all-time accumulative oil production.

Areas that have not been extensively explored are those south of the Artesia and Vacuum fields.

Central Basin Platform

The Central Basin Platform has been extensively developed, and is presently being developed at a rapid rate. The platform is bordered on the west by the Delaware Basin, and on the north by the San Simon Syncline. The Guadalupe back-reef section is productive of oil and gas from the north end of the platform extending southward into Texas. Older Permian, Devonian, Silurian, and Ordovician sediments are prolific reservoirs on such major structures as the Monument, Eunice, and Dollarhide. The Central Basin Platform was formed during late Pennsylvanian time, and underwent intense mountain building during this era. The intensity of this orogeny is indicated on the Eunice High where over a mile of section had been removed by erosion before the Abo formation was deposited. The Abo formation rests with angular unconformity on all older rocks and overlies the Precambrian on

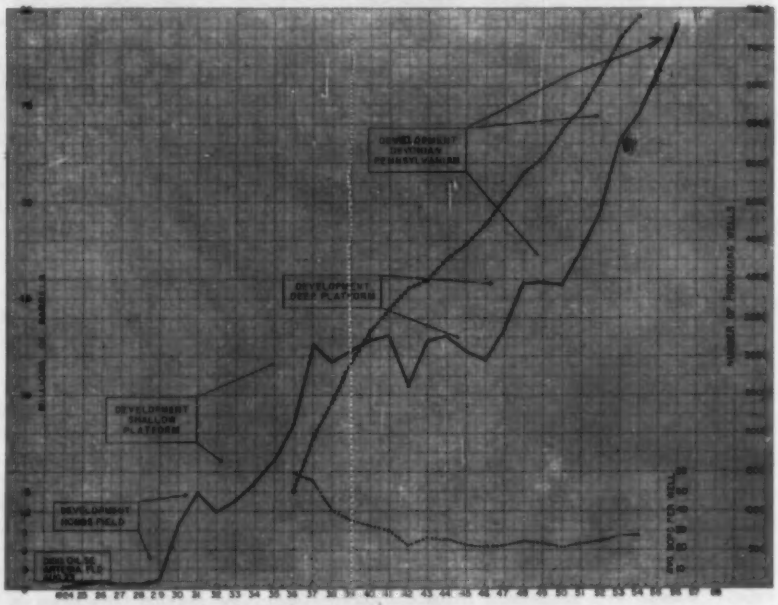


FIG. 2. **Southeastern New Mexico oil development** has skyrocketed since oil was first discovered in the Southeast Artesia field 32 years ago. Estimated total oil recovery this year is 87,000,000 bbl.

the eastern edge of the Eunice High.

Many of the large structures such as Hobbs, Justis, and Arrowhead are as yet incompletely tested, although the area is still being extensively developed after 28 years of drilling. The Eunice High has proven to be productive in 11 horizons. The Dollarhide, Monument, and Fowler are productive in five formations. All fields on the Central Basin Platform are multi-pay.

Of the 10 largest fields in the state in accumulative production, the Central Basin Platform has six which are as follows:

Rank	Field	Formation	Accumulative Production to January 1, 1956
1	Eunice-Monument	Grayburg-San Andres	251,735,317
2	Hobbs	Grayburg-San Andres	149,870,915
4	Jalmat	Yates-Seven Rivers	43,113,246
5	Drinkard	Drinkard	40,804,563
6	Langlie Mattix	Queen	33,858,566
10	Brunson	Ellenburger	22,780,583

It is of interest to note that only 25 oil fields in the United States have produced more oil than the Eunice Monument field. The recovery in the Hobbs field has exceeded 13,000 bbl of oil per acre, and 70 per cent of the wells are still flowing.

The oil produced from fields on the Central Basin Platform accounts for 67 per cent of the state's all time production.

Northwestern Shelf

The Northwestern Shelf is the area north of the Artesia-Vacuum Trend. The production is in the main from the Wolfcamp, Pennsylvanian, and Devonian formations at depths below 9000 ft, although the Caprock-Queen and Lovington fields are at shallower depths and produce considerable quantities of oil.

The lithology of the Silurian and Devonian is very similar in the northern portions of Lea County, and some controversy exists as to the correct age of some of these fields. For statistical purposes these fields are considered to be Devonian in age. Some fields in the Northwestern Shelf area are designated as Wolfcamp, Permo-Pennsylvanian, and Pennsylvanian in age. Many workers consider most of these fields to be Wolfcamp.

Most of the deeper pools of the Northwestern Shelf are on north-south trending folds. Due to the depth factor in the states proration formula the Northwestern Shelf area is producing an ever increasing percentage of the state's production. The percentage for 1955 is in excess of 43, but as to total accumulative production it accounts for only 12 per cent. This reflects the recent rapid growth of the area.

Some wells in the Denton field have in excess of 500 ft of pay indicating somewhat the expected recovery from these deeper fields. The Crossroads has recovered over 9000 bbl of oil per acre, and many of the structures are productive in both the Wolfcamp and Devonian.

GENERAL GEOLOGY

Precambrian

According to Flawn, the Precambrian is a suite of complex metasedimentary, volcanic, and plutonic rocks. The basement rocks are more than 19,000 ft in the deeper portions of the Delaware Basin. On the eastern edge of the Eunice High, basement rocks are encountered around 7300 ft. Northward from the Delaware Basin the rise is gentle and the basement rocks are some 10,000 ft deep in northern Lea County.

Cambrian

No sediments of Cambrian age are identified in Southeastern New Mexico.

Ordovician

The Ellenburger formation overlies the eroded Precambrian surface, except in those areas where the Ellenburger has been removed by erosion. The average thickness is about 350 to 400 ft and predominantly a carbonate section. The Ellenburger generally becomes thinner to the northwest.

Four fields have produced three per cent of the state's all time production, and for 1955 the Ellenburger will produce about four per cent of the production. All of these fields are located on the Central Basin Platform. The Brunson is the largest producing Ellenburger field and the tenth largest in accumulative production in Southeastern New Mexico.

The Simpson is Middle Ordovician in age, and consists of alternating sandstone and carbonate rocks. The McKee sandstone is the only producing formation in the Simpson. Six fields, all of which are on the Central Basin Platform, have produced a little over 1½ per cent of the states accumulative production. The McKee will account for about four per cent of the 1955 production.

The Montoya formation is Upper Ordovician in age and it is a carbonate section containing numerous chert stringers. The formation reaches 400 ft in thickness in southern Lea County, but thins northward. Only three wells have been completed in the Montoya, all of which are in the Cary pool on the Central Basin Platform.

Silurian

The Fusselman formation is Middle Silurian in age and the Upper and Lower Silurian are not present in Southeastern New Mexico. The sediments are carbonates and shales in which the Fusselman reservoirs often have cavernous porosity.

The Fusselman is productive in three fields, all of which are on the Central Basin Platform. The production from these fields has not exceeded one per cent of the accumulative production.

Devonian

The Devonian is presently the object of intensive exploration work. It is a dolomite section of Lower Devonian age becoming less dolomitic southward. During Upper Devonian time the Woodford sea transgressed upon the area depositing a black calcareous shale that reaches 600 ft in thickness and wedges-out along the northern border of Lea County. This formation has

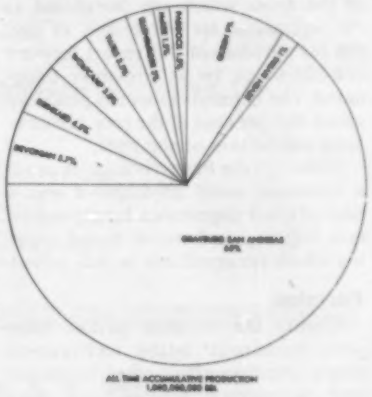


FIG. 3. **Grayburg and San Andres** accounts for 65 per cent of Southeastern New Mexico's accumulated oil production. Devonian oil is taking a larger share of the "pie."

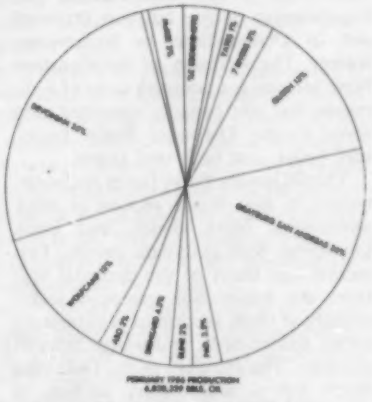


FIG. 4. **Monthly production** records indicate that this part of the state's principal oil producing zones are changing in importance. Note the value of Devonian, Queen and Wolfcamp production as against all-time record in Fig. 3.

been removed by erosion over much of the Central Basin Platform.

Presently 28 Devonian fields are producing some 24 per cent of New Mexico's 1955 production. The rapid development of the Devonian fields is indicated by its having produced only slightly more than five per cent of the accumulative production for the state. Three of the Devonian fields are on the Platform, and the remaining 25 on the Northwestern Shelf.

Mississippian

The Mississippian "lime" is some 1500 ft thick and thins northward to a feather edge. Two wells have produced 7000 bbl of oil from the Mississippian.

Pennsylvanian

The Pennsylvanian sediments are primarily carbonates 1000 to 3500 ft thick with beds of detrital shale. Many of the fields which are designated as Pennsylvanian are Wolfcamp in age, but for purposes of this report they are considered to be as presently designated. The Pennsylvanian has produced about two per cent of the total accumulated production of the state.

Although the Pennsylvanian is as yet a relatively small producer it was a time of great importance for the mountain building and major broad warping which occurred late in this period.

Permian

During the Permian period there were numerous inland embayments where circulation was often restricted, and depositional environments were constantly changing. This was a period of great reef development, and as the Permian sea regressed the reef transgressed upon the older Delaware Basin deposits. The reef development reached spectacular proportions during the Guadalupian Series, but was drowned out in Ochoa time by hypersaline waters. The Permian of Southeastern New Mexico is a complex suite of sediments that are broadly classified into three facies: Delaware Basin facies, reef facies, and back reef facies.

The Delaware Basin facies is characteristic in that it is a section of thick sandstones, black shales, and black limestones with abundant fossils. This section has many of the desirable features the exploration geologist seeks; namely at thick section of sedimentary rocks, source beds, and wedge belts of porosity. The Permian of the Delaware Basin has a sedimentary section in excess of 10,000 ft, and as to source beds the basin abounds in organic remains. The wedge belts of porosity are present throughout the area of the reef developments.

The reef facies is characteristic in that it is a thick section of carbonates with rapid vertical development containing abundant fossils in the outcrop, with wedges of both the basin and back reef section abutting against and into the reef.

The back reef facies is characteristic in that it is a section of thin sandstones often red, precipitated dolomite, thick beds of anhydrite, halite, red shales, and oil fields.

Wolfcamp

In the Delaware Basin the Wolfcamp is a dark shale and black limestone deposit grading northward into a gray limestone. On the Northwestern Shelf many important oil reservoirs are present such as the Denton Wolfcamp field, the Saunders field, and the Townsend field. All of the Wolfcamp reservoirs are located on the Northwestern Shelf. The Wolfcamp formations have produced about 1½ per cent of the state's all time accumulative production. Due to recent development of numerous fields the Wolfcamp will produce in excess of 12 per cent of the 1956 production.

Leonard

The Abo is the basal formation of the Leonard back reef section. It is a carbonate section, and becomes red beds of continental origin in the vicinity of Lovington. The Abo overlies older formations in areas of intense diastrophism, such as the Eunice High, with angular unconformity. Four fields have produced oil from the Abo formation, three of which are on the Central Basin Platform, and the Lovington-Abo field on the Northwestern Shelf. The Abo has produced about one-half of one per cent (0.5 per cent) of the state's all-time total, but will produce in excess of two per cent for 1956. The basin facies equivalent is the Bone Spring formation which has produced less than 3000 bbl of oil from three wells.

The Yeso formation is conformable over the Abo, and contains several producing horizons. At the base is the prolific Drinkard pay. The Tubb is important as a gas producing horizon, and the Blinebry is productive of both gas and oil. The uppermost unit of the Yeso is productive of oil in the Paddock zone. Northward the Yeso becomes continental red beds.

The basin facies equivalent of the Yeso is Bone Spring; the reef facies is represented by the Victorio Peak "Lime Bank." The Drinkard will produce five per cent of the state's 1956 production, the Blinebry two per cent and the Paddock three per cent. The Yeso formation has 19 producing fields.

Guadalupe Series

The production from the Guadalupe Series accounts for 79 per cent of the state's all time accumulative production. The formations of the Guadalupe Series will produce in excess of 40 per cent of the state's production for 1956. This production will come from over 6000 wells in 101 oil fields.

It was during the Guadalupe Series that the Permian reefing reached such spectacular proportions.

Most of the production obtained in the Delaware Basin comes from the Bell Canyon section; it has 35 producing wells. The Brushy Canyon has five producing wells. The all-time accumulative production from the Delaware Basin is 0.04 per cent.

Glorieta

The Glorieta is a transgressing marine sand, and is productive of dry gas in the Justis gas pool.

San Andres

The San Andres is a thick carbonate section reaching 1500 ft in thickness. Only the upper few hundred feet have been proven productive. The San Andres is characteristic in that it often has cavernous porosity with an active water drive. This formation is productive of oil and gas in fields such as Eunice-Monument, Hobbs, Vacuum, and Grayburg-Jackson. The Grayburg and San Andres are often productive in the same fields. These two formations have produced in excess of 65 per cent of the state's production, from 28 fields.

Grayburg

The Grayburg is commonly known as the "sandy lime," and as stated, is often productive of oil and gas in the same fields as the San Andres and is included with the tabulation of the San Andres fields.

Queen

The Queen is the first major sand deposition since the Glorieta, and marks the beginning of the rapid departure of the Permian sea from this area. The Queen sandstones are very widespread and petroliferous, being productive on the Central Basin Platform, the Northwestern Shelf and the Artesia-Vacuum Trend. The Queen sandstones are productive of dry gas in the Eumont Gas field, and the Byers-Queen gas field. The Langlie-Mattix and Caprock-Queen fields are both large producers of Queen oil. The Queen is at present being actively developed. The Queen has produced over nine per cent of the state's total accumulative oil production but will exceed 13 per cent for 1956.

Seven Rivers

The Seven Rivers formation is composed of sandstone, dolomites, anhydrites, and red beds. Although the

Seven Rivers formation has produced only one per cent of the state's total oil production it is often very prolific in areas such as the Wilson, and Cooper-Jal fields. The dry gas of the Seven Rivers formation is found in the Jalmat and Eumont gas fields.

Yates

The Yates is primarily a sandstone, and it contains large reserves of dry gas in the Jalmat and Eumont gas fields. The Yates oil production is obtained in a relatively narrow band close behind the Capitan reef, but it also produces considerable oil from synclinal structures in the Jalmat gas pool. The Yates formation is the most widely used horizon for mapping in the Permian Basin, due to being diagnostic and the numerous points available. The Yates is presently producing about two per cent of the state's daily allowable, but has produced in excess of three per cent of the state's all-time total production. Three wells in the Lynch pool have each produced over 2,000,000 bbl of oil.

Tansill

The Tansill formation has favorable sediments for reservoir beds in a very narrow belt near the Capitan Reef. As yet no oil production is obtained from the Tansill formation, but the formation is productive of dry gas in scattered areas of the Jalmat gas pool. The Scanlon and Hale fields each have a dry gas well completed in the Tansill formation that has been shut in since completion.

Ochoa Series

The Ochoa series is principally a section of thick halite and anhydrite section which reaches 4000 ft in thickness. The salt section is important for the commercial potash. The Castile, in a local development of dolomite, has produced 1500 bbl of oil from one well. This is the youngest producing horizon in Southeastern New Mexico.

FUTURE POSSIBILITIES

Southeastern New Mexico now has more exploration drilling in progress than ever before, and is consistently one of the most active areas in number of drilling wells and geophysical activity in the nation. The recent trend of the oil producers establishing exploration offices in New Mexico is a significant fact. Recent discoveries, and the extension of numerous fields in the Guadalupe Series has again focused the attention of operators on these horizons. The deeper horizons of the Northwestern Shelf are being developed at a very rapid rate.

TABLE 1. The 10 Largest Oil Fields in Accumulative Production.

Rank	Field	Formation	Production to 1-1-56
1	Eunice-Monument	Grayburg-San Andres	251,735,317
2	Hobbs	Grayburg-San Andres	149,870,915
3	Vacuum	Grayburg-San Andres	74,017,608
4	Jalmat	Yates-Seven Rivers	43,113,240
5	Drinkard	Drinkard	40,804,563
6	Langlie Mattix	Seven Rivers-Queen	33,858,566
7	Grayburg-Jackson	Grayburg-San Andres	31,634,569
8	Maljamar	Grayburg-San Andres	30,138,774
9	Denton	Devonian	25,879,794
10	Brunson	Ellenburger	22,789,583

TABLE 2. The 10 Largest Fields in Production for September, 1956.

Rank	Field	Formation	Production
1	Eunice-Monument	Grayburg-San Andres	818,153
2	Denton	Devonian	605,180
3	Caprock-Queen	Queen	426,906
4	Vacuum	Grayburg-San Andres	319,001
5	Hobbs	Grayburg-San Andres	271,339
6	Townsend-Wolfcamp	Wolfcamp	207,915
7	Maljamar	Grayburg-San Andres	190,812
8	Denton-Wolfcamp	Wolfcamp	189,298
9	Langlie Mattix	Seven Rivers-Queen	172,304
10	Drinkard	Drinkard	160,433

ADVERTISING INTEGRITY . . . and THE PUBLISHER'S RESPONSIBILITY

RELATIONSHIP of publisher and his reader is one of trust and obligation. Power of the printed word is potent, not only in technical publications but in the daily press as well. It behooves any publisher to make certain that what is conveyed in the "editorial" pages is accurate. This is especially applicable to the petroleum industry. Important decisions are made upon information printed in various oil trade publications. The solution to acute and costly problems is often found in these journals.

The problem is more complicated when it comes to advertising. When a manufacturer, supplier or service firm purchases advertising space in a trade publication, it is almost comparable to the purchase of land. It is his to do with as he chooses **but** he must conform to codes, ethics and laws.

Within this area comes the publisher's responsibility to the reader. Not only must advertisements conform to certain laws pertaining to the printed word (especially if delivered by the U. S. mails), but what the advertisement says must be carefully scrutinized by the publisher to insure its conformation to prudent publishing policies and practices.

No publisher can afford to endorse or appear to endorse products or services advertised. In his enthusiasm, the copywriter and/or artist may tend to present the advertisement in a form not unlike that found in the editorial content of the publication. Although the publisher cannot prohibit the use of type faces normally employed in editorial content, he can, in pursuit of his obligation to the reader, use the word "advertisement" in the margin, usually outside the space purchased by the advertiser. When an advertisement has a general overall appearance similar to editorial content, (or for similar obvious reasons), it is common practice to use the "advertisement" label.

The publishers of *The Petroleum Engineer* have conformed to this practice which is followed by most trade publications, as well as national magazines. In the haste to complete an issue by the "deadline," errors and omissions will occur. In the recent November, 1956 issue of *The Petroleum Engineer*, such an omission was made. On page B-170, a full page advertisement by the McEvoy Company used similar type faces (although of a different size) as those used in the editorial pages. This advertisement was interpreted by some as a companion editorial and advertisement (since a one-column ad appeared on the page).

The words "Ad Editorial" displayed prominently in the upper left hand corner of the page might have been interpreted as an editorial endorsement. This was not the case, and should have been deleted to eliminate any possible confusion.

Omission of the label "advertising" in this case does not carry with it any intent to mislead the reader, nor does it imply any endorsement. It was an omission made in honest faith, and one which sharpens our focus for similar situations in the future, not only in keeping with our policy, but to preclude confusion or misrepresentation.

For greater return from your compressor investment

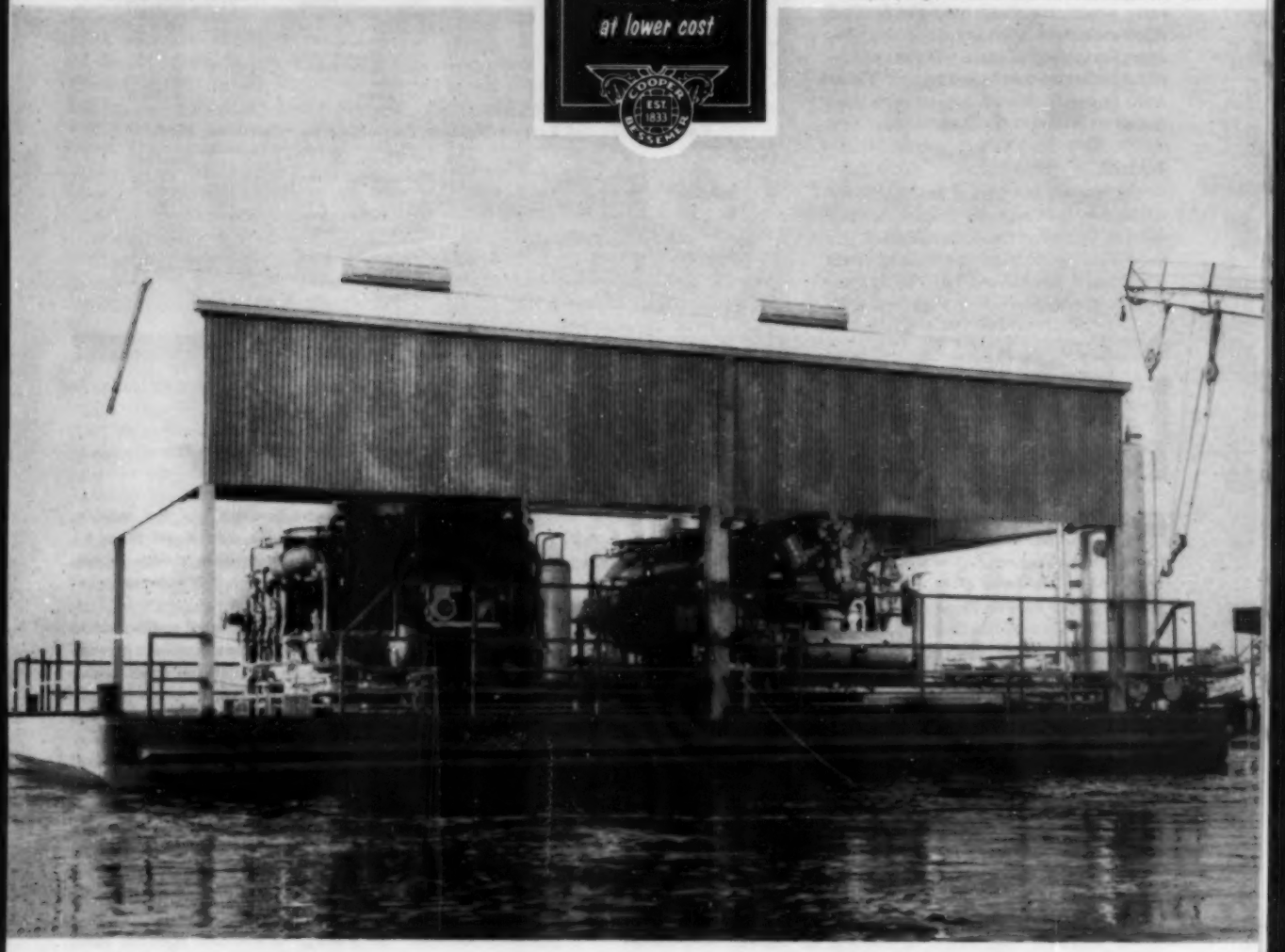
. . . . check the advantages of the

COOPER-BESSEMER COMPLETELY PACKAGED GMXD

Another example of efficient power at lower cost

Below: Packaged by Southwest Industries these barge mounted Cooper-Bessemer GMXD's handle natural gas compression at this Louisiana Gulf Coast installation of The California Company.

Right: Six-cylinder Cooper-Bessemer compressor installed by Southwest Industries in the Sohio Petroleum Company's gas booster station near Houston, Texas.



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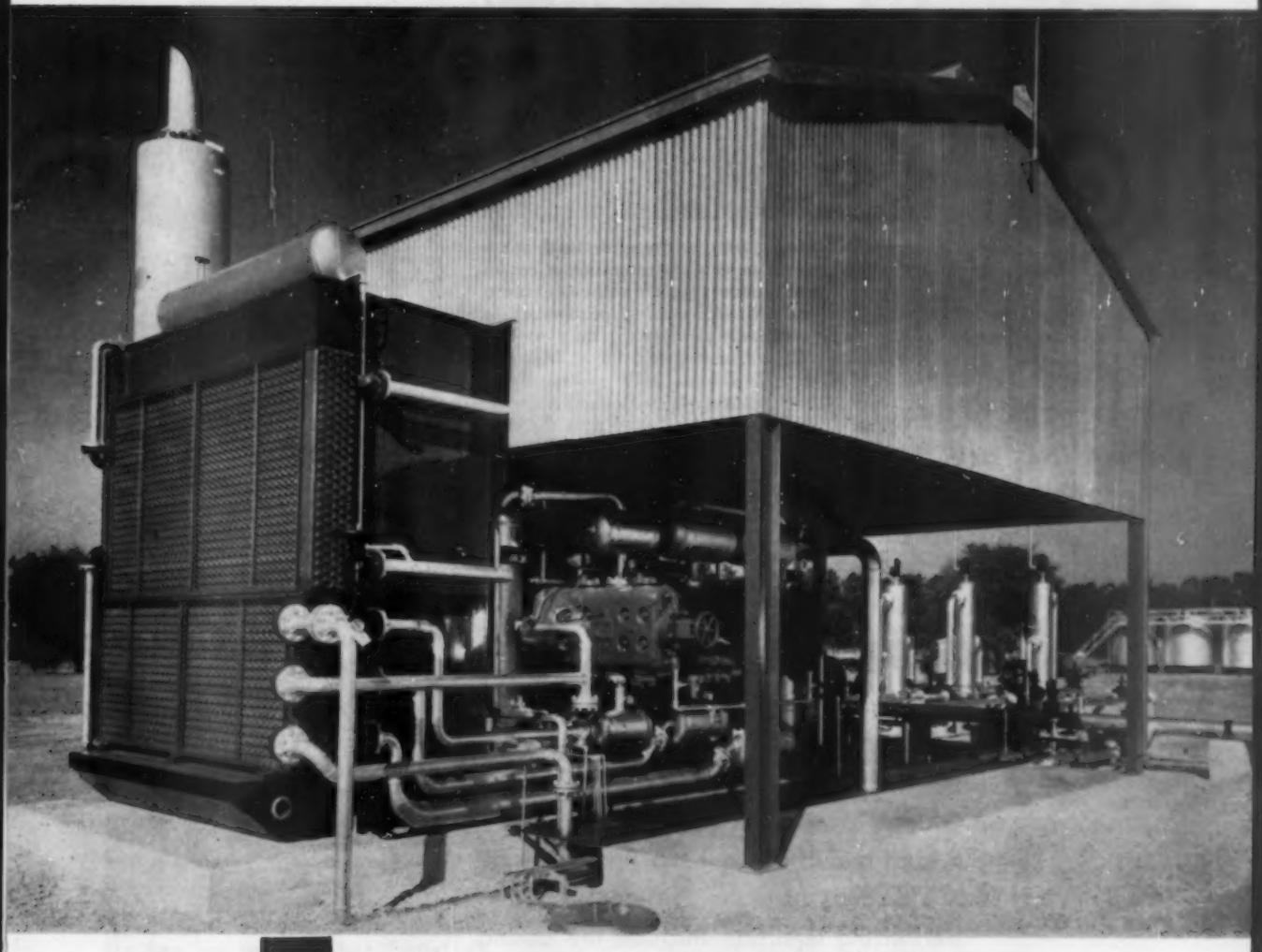

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Stage fracturing with ball sealers is newest idea for sealing casing perforations. Typical equipment hookup with ball sealer injection unit in foreground at right.

Rubber balls to seal perforations are . . .

Newest Aid to MULTI-STAGE FRACTURING

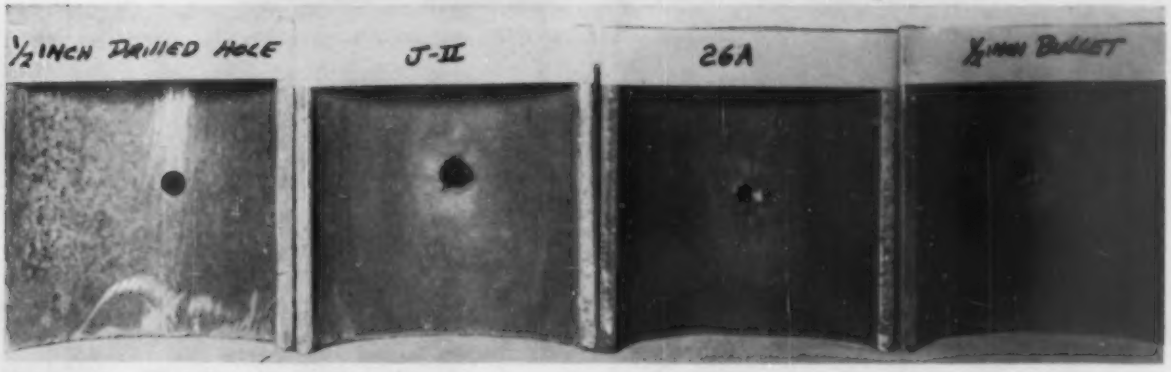
Simple idea is cutting well treating costs by sealing off zones of higher permeability and permitting injection through the casing

J. E. Kastrop, *Editor,*
Exploration, Drilling and Producing

WELL stimulation by multiple-stage hydraulic fracture treatments in one well is being accelerated in the Permian Basin of West Texas and Southeast New Mexico by a brand new and simple device . . . small rubber balls. Measuring ⅞-in. in diameter, these balls are injected at the surface into the fracturing stream between each frac stage. Their purpose is to seal off casing perforations opposite the more permeable zones, permitting controlled fracturing of the less permeable horizons through casing perforations not sealed by the rubber balls. The number of these balls injected into the fracturing stream (usually in the flush fluid at the end of each stage) is determined by the number of perforations desired to be sealed. In actual field practice, the number of balls used between frac stages will usually exceed slightly the total number of perforations to be sealed. For example, if it is estimated that there exist 80 perforations to be closed off for the next fracturing stage, about 85 to 88 rubber balls will be used. Previous experience in the area, core analysis data, log studies or injection surveys have been employed to determine those intervals to be sealed during a multi-stage fracture treatment. By knowing the number of perforations per foot and the length of the interval, the total number of perforations to be sealed can be calculated.

Why stage frac? Benefits of multiple stage fracturing have been well established, especially as they apply to producing intervals with varying permeabilities. Naturally, it is the objective to create additional fracture channels throughout the producing interval, and not concentrate in just one zone or horizon. Variable permeabilties or permeability streaks frequently exist in a single producing formation and one section will take injected fluid much faster than other sections. In the case where there are exposed to the bore hole several separate and distinct producing zones or formations, and all have been perforated so they produce into a common flow stream (into the casing), it is likely and frequently occurs that one of these zones will be more permeable than the other. And, therefore, this zone will take injected fluid more rapidly and in greater quantities than the less permeable zones.

When a fracturing fluid is injected into this perforated interval, whether it be a long pay zone or several separate



Perforations sealed by rubber balls. Coupons from 5½-in. casing showing size and shape of hole sealed. At left is ½-in. drilled hole; heavy-duty jet perforation; conventional jet perforation; and ½-in. bullet perforation.

and distinct zones, the amount of fluid injected into each zone will vary with permeability of that section. From a results and operating standpoint, it is highly desirable to inject fracturing fluid into all producing sections to create additional flow channels and thereby increase the productive capacity of every section. However, if one or two sections take all the fluid, the remaining sections that are "tight" or less permeable, will not receive very much benefit from the fracturing treatment. Even though permeabilities vary, it is desirable to create or enlarge drainage channels in all producing sections.

Multiple-stage fracturing. Recognizing early that to obtain best results from well stimulation by fracturing, it would be necessary to provide a means whereby all producing zones could be treated. Since one zone took most of the frac fluid, it was necessary to isolate that zone while the next permeable section was fractured. In some cases, additional zones of lesser permeability were exposed to the well, and in order to treat these tighter zones, the more permeable zones previously treated had to be isolated.

Before the advent of perforation ball sealers, several methods were employed to selectively fracture separate zones: (1) Packers; (2) progressively perforating and setting bridge plugs; and (3) use of thick gels and/or lost circulation materials.

These methods are frequently effective and have been used for a number of years. Packers are effective, particularly when used in casing. But, their use is time consuming and expensive from the standpoint of rig time required to round trip the tubing and packer. Treating through tubing also restricts the rate of injection and uses up power in friction loss that could otherwise be applied to the formation being treated. When straddle packers are used, there exists the possibility of sandouts that cause expensive fishing jobs.

Progressive perforating and setting bridge plugs is effective and has been utilized for good results, but this method is expensive and time consuming.

Application of thick gels and/or lost circulation materials is a step in the right direction. However, the number of wells where this method can be used reliably is somewhat limited. First, it is recognized that fractures are difficult to seal off, as has been demonstrated by lost circulation problems in rotary drilling. It is also difficult to determine how much sealing material should be used. If not enough is employed, the zone will not be plugged off adequately. If an excess amount is used, it might also seal off the zone that is to be treated unless it is isolated by a packer. In the later case, the disadvantages of using packers would apply.

Idea behind ball sealers. The idea behind the perforation ball sealers is graphically demonstrated in Fig. 1. This is a schematic of the hole showing two perforated intervals in the casing. The lower zone is more permeable and takes injected fluid at higher rates than the upper zone. This is a case for a two-stage fracture treatment. Job is to be done down the casing, and tubing is out of the hole.

Treating fluid is injected into the well and it enters perforations opposite the most permeable zone . . . in this case, the lower formation. Rubber balls

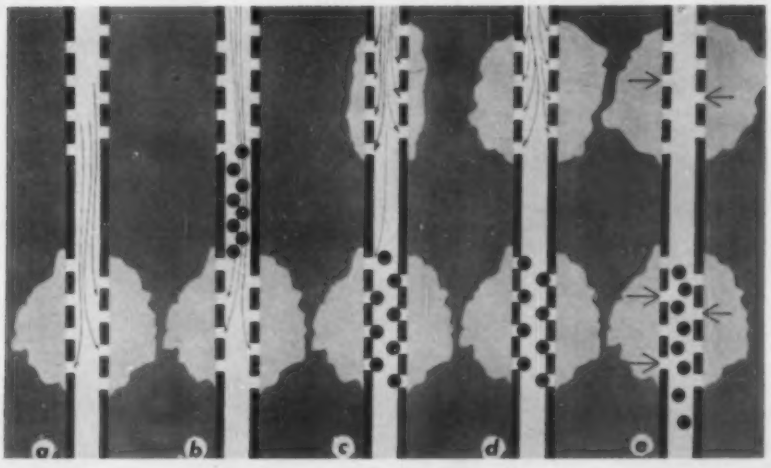


FIG. 1. **Ball sealer principle** is shown in simplified form. (a) Lower perforated interval fractured in first stage; (b) ball sealers pumped in with flush fluid; (c) casing perforations of lower zone sealed by balls; (d) upper zone fractured in second stage; and (e) balls fall to bottom when pressure differential released.

Wellhead hookup for six-stage frac job showing one pump truck in background. Encircled is transducer that transmits electrical impulses to pressure recorder unit to record casing pressure during entire treatment.

Electrical pressure recorder mounted in car trunk. Treating engineer is recording pressures on job data sheet.

are injected into the flush fluid following the frac treatment on the lower formation. Since the lower perforated interval readily takes fluid, these balls follow the fluid stream to the perforations where they provide a seal due to the differential pressure holding them in place.

Pressure on the well is never released, and the second fracturing stage immediately follows the first stage flush. Since the lower perforations are sealed, pressure builds up and the formation opposite the upper perforated interval is broken down and frac fluid injected. It is followed by the desired amount of flush, usually equal to the casing volume.

Upon completion of the two-stage fracture treatment, pressure on the wellhead is released, and the differential pressure from the formation toward the well bore causes the rubber balls to be released from the perforated holes. Due to their slightly higher specific gravity, they fall to the bottom of the well.

If the presence of the rubber balls on bottom is objectionable, they may be recovered by means of a bailer, or they can be washed from the well by a high rate of flow if the well is capable of flowing. In most wells treated thus far, the rubber balls are left on bottom.

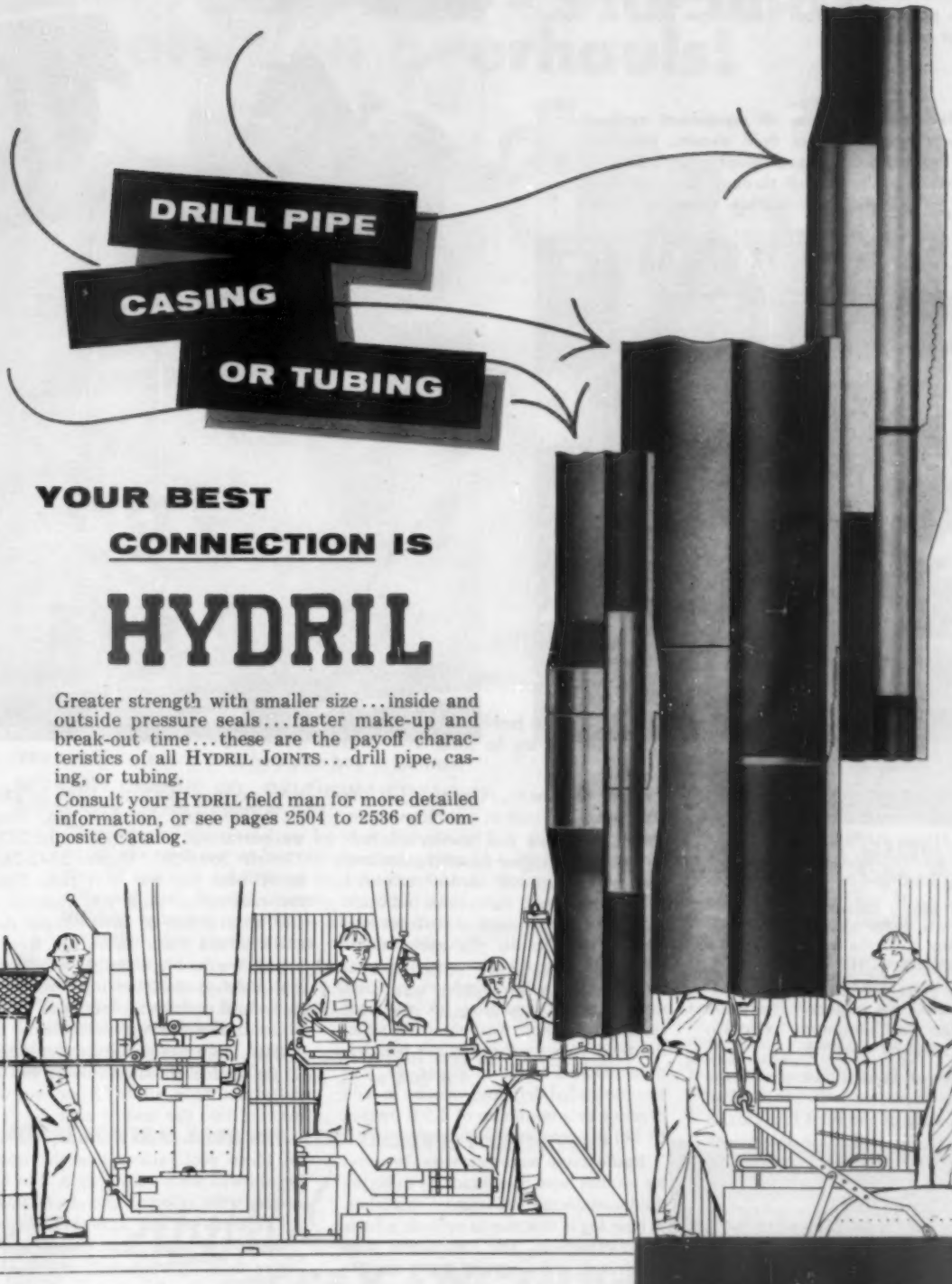
Requirements of ball sealers. To be practical and effective in sealing off casing perforations in multi-stage frac treatments, the balls used must meet the following conditions:

1. They must be of such a size and density to be retained in the fluid stream in order that each ball will be directed to and held on a perforation.
2. They must be hard enough so they will not be extruded through the perforation under pressure differentials encountered in actual field practice.
3. Not only must they adequately seal the perforation during frac treatments, but they must free themselves from the perforation when the pressure differential is released.
4. They should be of such specific gravity that they will settle to the bottom of the well when released.
5. They must be drillable.

Ball characteristics. Considerable

Inserting balls into tube system. Note hydraulic hose connected to tube in background. Engineer is loading rubber balls into tube by elevating end slightly. Swab is shown leaning against box.

Swab and balls used are shown in comparison to a man's hand. Rubber balls are ⅞-in. in diameter and fit inside .937-in. ID tube. Swab forces balls into frac fluid flow stream.



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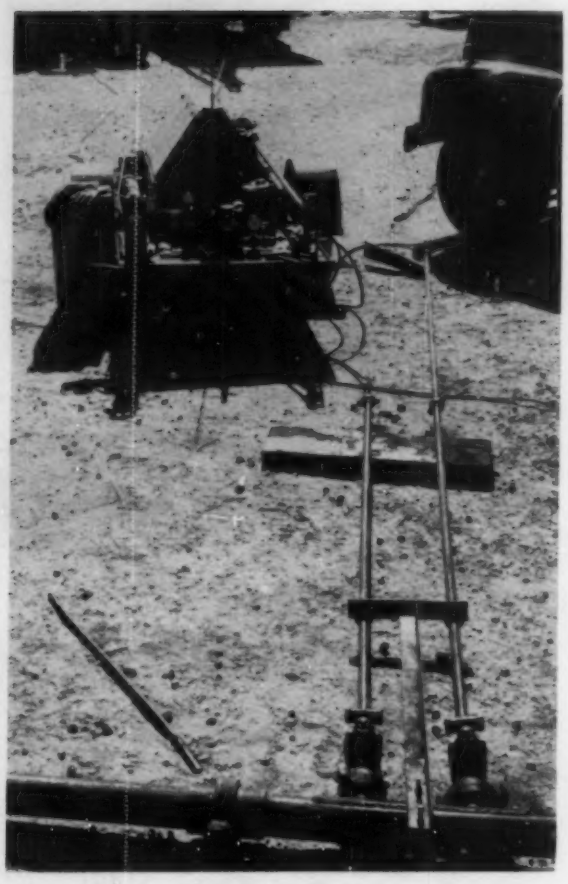
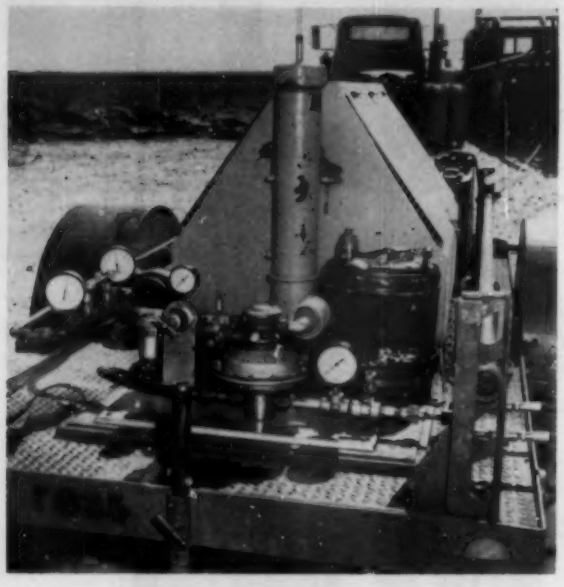
Ball sealer hookup showing parallel tube system connected into 4-in. header. Flexible hoses carry high pressure oil from diaphragm pump on trailer to far end of tubes.



Ball sealer trailer carries all equipment needed to introduce balls into frac fluid stream. Note oil reservoir in background and diaphragm pump in foreground. Air is supplied through lines at left; hydraulic oil pumped out flexible hoses at right.



laboratory and field testing indicated that best results were obtained by a ball made of Hycar rubber and ⅞-in. in diameter. Its specific gravity was 2.75 and had a hardness of 70 durometers (resilience scale for materials softer than metal). When tested on actual perforations, these balls would form a seal with as little as 100 psi differential. On several extrusion tests, up to 10,000 psi differential was required to extrude some balls. The minimum extrusion pressure recorded was 9500 psi.

Viscosity of fluid. Efficiency of the ball sealers increases with an increase in the viscosity of the fluid that carries them down the well. One laboratory test of sealing efficiency (per cent of holes sealed) with varying viscosity showed following results:

Fluid Viscosity (centipoise)	Velocity (ft/sec)	Efficiency (per cent)
8500	constant	33
14,000	constant	100
1300	1.73	77
1	2.42	73

Effect of velocity. Velocity of a moving column of fluid carrying the ball sealers is one of the critical factors effecting sealing efficiency. Specific gravity of the rubber balls is such that they will fall slowly in most fluids used in fracture treatments. Therefore, if the fluid is not injected at a sufficient rate, sealing efficiency will be effected. Surface tests in 5½-in. J-55 casing that had been jet perforated (holes measured about .5 in.) with eight shots indicated that at a fluid velocity of 4 ft per sec, 100 per cent sealing efficiency was attained. When similar velocity tests were made on flow through perforations, it was found that 100 per cent sealing efficiency was obtained when the fluid velocity through the perforations reached about 13 ft per sec. It is recommended that fluid velocity in field practice be a minimum of 2.5 ft per sec (4 bbl per min in 5½-in. casing).

Radioactive tracer surveys. Injectivity profiles have been made by injecting fluid containing radioactive materials. A base log is first run to provide a basis for comparison. The radioactive fluid is injected, and a second log is run. By comparing the two curves, it is possible to determine where the injected fluid is going. This type of study was made on a number of wells to demonstrate the effectiveness of the perforation ball sealers. Fig. 2 shows results of one such tracer survey.

The well is located in the H & M Glorieta field of Scurry County, Texas. It was drilled to a total depth of 2892 ft. A base log was first run. Then, was perforated at three intervals: 2776-2787 ft, 2804-2832 ft, and 2842-2848 ft. A base log was first run. Then, the radioactive fluid was injected at 100 psi at a rate of 2880 bbl per day, and a second tracer survey run. Results are shown on Fig. 2 (right hand log), and indicate that the top two zones took fluid equally according to length of perforations. The lower zone did not appear to be taking any fluid. About 25 per cent of the fluid entered the top perforated zone, while 75 per cent was injected into the middle zone.

The well was then fractured. To seal off those perforations that the tracer log showed were taking fluid, 184 ball sealers were injected ahead of 10,000 gal of green oil and 20,000 lb of sand.

After the treatment, more radioactive fluid was injected and another tracer log run. Results are shown by the dotted line in the second set of curves from the right on Fig. 2. Note that the bottom zone broke down and took the radioactive fluid, with the two top zones taking about the same amount of fluid as indicated by the previous tracer log. Based on these tracer logs, it was estimated that the

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bottom zone took about one-third of the fluid. The logs show some communication from the bottom set of perforations to total depth.

The most significant feature illustrated by such surveys has been that a fracture system was created in the zone that previously did not take fluid. It can only be concluded that the ball sealers did provide a seal over those zones which prior to the treatment were taking fluid.

Introducing rubber balls. One of the early problems to crop up in connection with this new idea was that of a practical method of introducing the rubber balls into the frac fluid stream. The ball sealers must be injected slowly and not all at once. Also, it was necessary that the treating pressure be overcome in order to get the balls into the frac stream.

Out of several ideas tried, the method illustrated in Fig. 3 proved most practical and satisfactory. This hookup utilized air pressure supplied by the air-brake system from two trucks. By means of a diaphragm pump, this air pressure is multiplied 100 times in the form of hydraulic pressure. In this case, a light oil is used to force a small swab against the rubber balls placed inside a tube. This tube connects into a header which carries frac fluid to the well.

The ⅞-in. balls fit easily into 10-ft tubes with an internal diameter of .937 in. These tubes can be connected in parallel into the header if a considerable number of sealer balls are required. By flanging two tubes together in a parallel arrangement as shown in Fig. 3, as many as 500 balls can be used. The number of balls injecting into the frac fluid header is determined by the volume of hydraulic oil displaced from the fluid reservoir. A calibrated rod extends out the top of this reservoir and is fixed to a float inside that rides on the hydraulic oil. The rod is calibrated so that each mark represents 20 balls. the diaphragm pump forces oil from the reservoir into the tubes containing the balls. This oil acts on the swab which pushes the balls into the header. The entire unit is mounted on a small trailer.

Pressure records. A unique pressure recording system utilizes direct current from a car battery to drive the recording mechanism. A transducer is connected at the wellhead and two insulated conductors carry electrical impulses to the rear of the treating engineer's car where the pressure recorder is located. This electrical system eliminates long high-pressure hoses used previously, and decreases the hazard. From a safe distance, the treating engineer can determine how the treat-

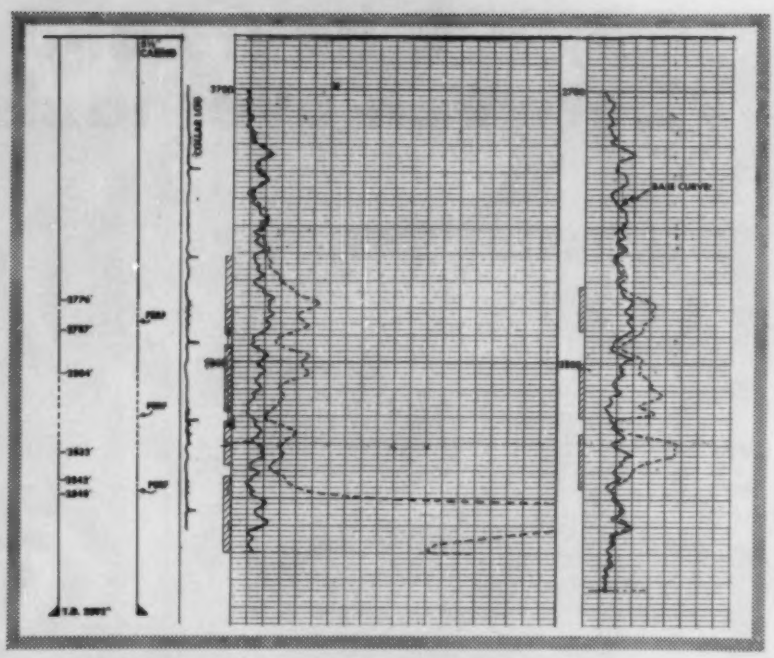


FIG. 2. **Radioactive tracer survey** shows injectivity profile before and after fracturing when ball sealers were used to seal off most permeable zones. Log at right indicates original conditions where bottom perforations are not taking fluid. Tracer log in center run after frac job with ball sealers indicates that bottom zone is taking fluid.

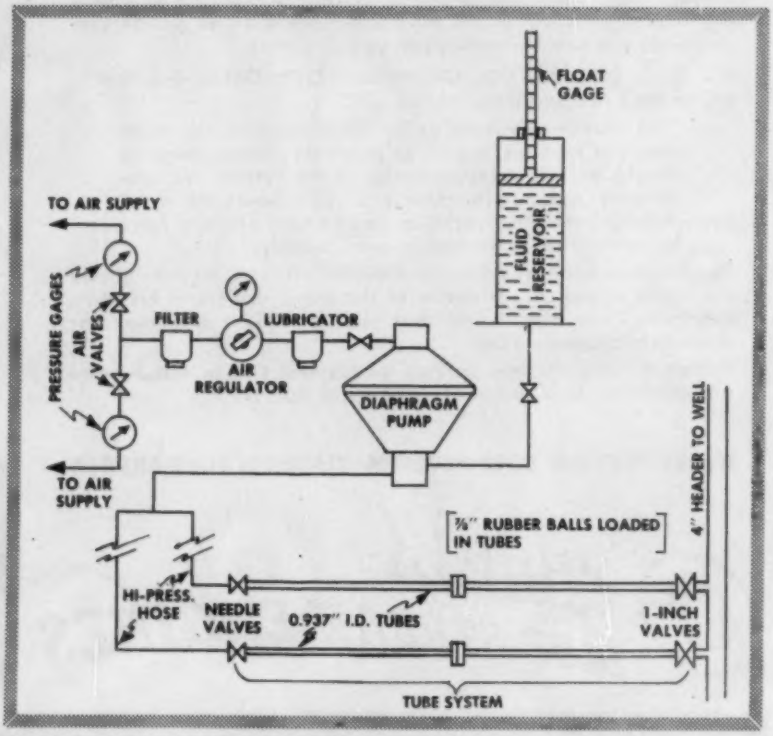


FIG. 3 **Method of injecting balls** is shown above. Balls are inserted in tube system and forced into header by swab which is activated by fluid pressure from diaphragm pump. Balls are counted by volume of fluid displaced.

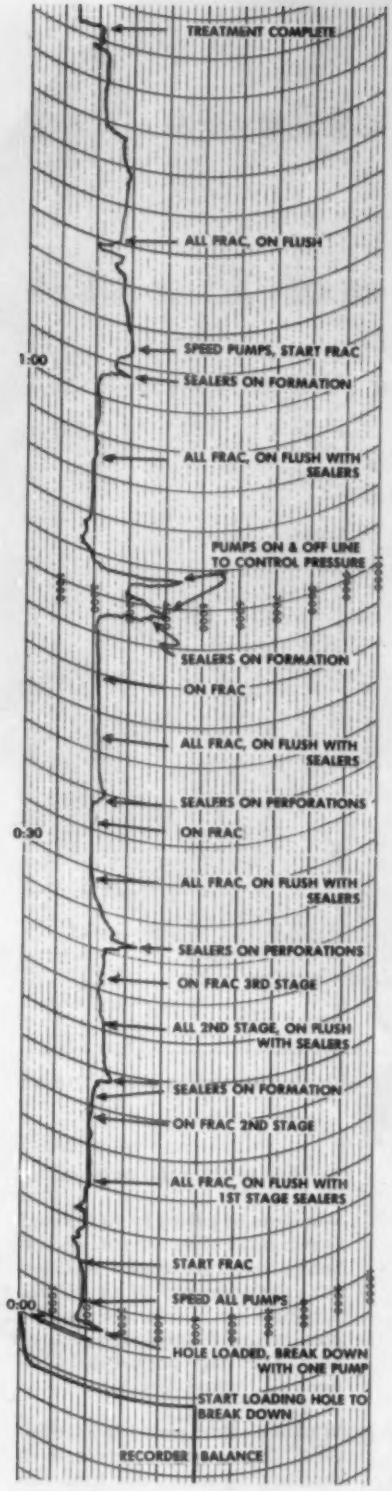


FIG. 4. **Pressure recording** of six-stage frac treatment utilizing ball sealers to isolate successive zones. Treatment consisted of 30,000 gal lease oil and 45,000 lb sand and a total of 300 perforation ball sealers. Note pressure buildup when balls seal perforations taking fluid.

ment is progressing by observing the pressure record as it is being made.

Fig. 4 is a pressure recording of a six-stage fracture treatment of 5000 gal of lease oil and 7500 lb sand per stage. The first stage was completed without ball sealers which were injected ahead of each succeeding stage. The 5-ball sealer stages consisted of the following number of balls: 90, 75, 45, 45, and 45. These ball sealers were injected in 50 bbl of flush oil between frac stages.

This well is located in the McElroy North field of Crane County. Top of perforations was at 3692 ft while the bottom perforation was at 3779 ft. Four and one-half inch casing was set at 3850 ft. Average injection rate was 20 bbl per min at an average casing pressure of 2500 psi. Maximum casing pressure was 4400 psi. All six fracture stages were completed in only about 1 hour and 40 minutes.

Fracturing with a future. Hydraulic fracturing of formations has experienced a phenomenal growth since its introduction about six years ago. Many significant developments have been made not only in the art but in fracture fluids and equipment used on the job. The operator has a large number of frac fluids from which to select, and modern equipment and experience make it possible to inject large volumes at high rates. The primary feature responsible for this tremendous growth in formation fracturing has been the results obtained. The high ratio of successes points toward continued growth. No longer is it common to fracture old wells on their last productive leg. But, a large percentage of fracture treatments are being made upon completion. Continued developments, such as described above that will increase the chance for fracturing success and cut costs, undoubtedly will accelerate this method of well stimulation.

Acknowledgment

Acknowledgment and appreciation go to The Western Company of Midland, Texas, for information, illustrations, and permission to publish this report. The author is especially grateful to the following Western Company engineers: George Neill, Bob Brown and Billy Halepeska. ★ ★ ★

Producer, Driller Renamed to API Posts

Jake L. Hamon

Frank M. Porter

D. L. Connelly

Jake L. Hamon, independent operator has been renamed chairman of the board of the American Petroleum Institute. Re-election of the Dallas, Texas, producer came in the closing sessions of the thirty-sixth annual API meeting, November 12-15, in Chicago, Illinois. Total registration, 6394.

Oklahoma City drilling contractor Frank M. Porter, was re-elected president. Porter is head of the Fain-Porter Drilling Company.

D. L. Connelly, Houston, Texas, is a newcomer to the API officer ranks. Connelly, director and senior vice president, oil production division of Warren Petroleum Corporation, was elected vice president for the API Division of Production.

Connelly, once an independent at Cisco, Texas, joined Gulf Oil Corporation as a scout and landman in 1922. Later he joined the former Indian Territory Illuminating Oil Company of Bartlesville, Oklahoma, eventually being advanced to manager of the Land and Geological Division.

In 1941, Connelly was transferred to Houston as manager of the Texas Land and Geological Division of Cities Service Oil Company and resigned that position in March, 1944, to head the newly-created oil production activities of Warren Petroleum. Connelly, in addition to being an API member, is a director of the Texas Mid-Continent Oil & Gas Association.

Connelly follows A. W. Thompson as vice president, API Division of Production. One of the last official acts of Thompson was to present nine oilmen with Certificates of Appreciation at the Tuesday afternoon session of the Production Division. Awards were given to: C. E. Beecher, Cities Service Oil Company, Bartlesville; W. O. Clinedinst, National Tube Division of U. S. Steel, Pittsburgh; Everett P. Hayes, California Texas Corporation, New York; W. F. Herbert, The Texas Company, Houston; S. S. Parker, National Tank Company, Dallas; W. V. Vietti, The Texas Company, Houston; John Woodruff, University of Texas, Austin; J. C. Slonneger, Continental Supply Company, Dallas, and Morgan Davis, Humble Oil & Refining Company, Houston.

A new look at...

Air Drilling Practices In The Permian Basin

Here are the problems and part of the solutions.

F. W. Smith
Technical Drilling Service, Inc., Midland, Texas

H. M. Rollins,
Drilco Oil Tools, Inc., Midland, Texas

THE use of air in the drilling, completion and workover of wells is now past the trial stage in the Permian Basin. The method has proven to be an economical and practical means of solving many of the inherent problems of drilling liquids. In the past year, air-drilling has become widespread throughout this area. This is graphically illustrated in Fig. 1.

Many wells are air-drilled today from under the surface pipe to total depths of 3000 to 4800 ft, effecting savings of $1500 to $9000 per well. Even as little as 1000 ft of hole has been air drilled from under the intermediate pipe, saving $2000 to $3000. In Val Verde County, Texas, 7500 to 8000 ft of hole has been cut by air.

The deepest hole drilled with air or gas so far was a wildcat drilled to 13,300 ft in Lea County, New Mexico.

FIG. 1. **Drilling and working over** wells with air is spreading in the Permian Basin of West Texas and New Mexico.

Advantages and Disadvantages of Air Drilling

Summed up, here are the advantages of drilling with air or gas:

1. A 50 to 200 per cent increase in penetration rate.
2. A 50 to 300 per cent increase in bit life.
3. Truer gage hole — less cement required.
4. Continuous drillstem test.
5. No damage to pay sections.
6. No lost circulation problems.
7. No drilling fluid costs.
8. Rig operating costs lower—(mud pump and drilling line savings).

Here are the disadvantages of drilling with air or gas:

1. No practical way to shut-off water flow.
2. Samples are small or powdery — requiring new techniques of interpretation.
3. Increased difficulties in controlling high-pressure zones.

Primary Considerations

Many wells drilled in the past were not successful because of lack of planning or incomplete data on the formation to be penetrated. Before moving air tools on a location, three questions should be answered:

(1) What is to be gained?

(2) What are the difficulties?

(3) How to solve the problem?

1. **What is to be gained by air drilling?** One or more of the advantages outlined above can be used to determine the economics of air drilling. A comparison of drilling costs, pipe programs, and completion costs on offset wells helps answer this question.

2. **What difficulties would be encountered?** The first step is to locate all fluid-bearing formations from surface to total depth of the well. Fluid-bearing formations that are not cased off will in most cases, shutdown air or gas drilling. Fluid zones should be cross plotted against the standard pipe program to determine if these wet zones should be cased off. In many wells,

Season's Greetings from SCHLUMBERGER

an extra 100 to 300 ft of pipe, either surface or intermediate, may open up long sections of hole that could be air or gas-drilled. Also, it should be determined whether crooked hole or lost circulation is to be a problem. In most lost circulation zones it has been found that fluids usually invade the bore hole 15 to 30 ft below the weak or fractured section of the hole.

3. **How to solve the problem or problems.** In order to reduce drilling cost through use of air, gas or aerated mud circulation, not only must the casing program be carefully planned and studied, but the right type of surface equipment must also be selected. (See Fig. 2).

Air Volume

The individual problem with which you are concerned determines the type of air-drilling equipment that must be used. For straight downhole drilling where no fluids are encountered, low-pressure, high-volume air compressors can be used. It has been determined from past experience that it is necessary to circulate enough air to give 4000 to 5000 ft per minute annular velocity in soft formations and from 3000 to 4000 ft per minute in hard formations.

Water Problems and Solutions

In drilling with air or gas as a circulating medium, the principal difficulty comes from liquid in the hole — either oil or water. These liquids dampen the dry cuttings, often causing them to plaster against both the wall of the hole and the drill pipe. When the cuttings bridge, they sometimes stick the pipe.

Three types of moisture conditions give the most trouble. The first is a damp, sticky formation which either swells or picks up dry cuttings as they are circulated past the moist zone. If the build up is sufficient, it means stuck pipe. A second type is even more hazardous. It is the one which produces just enough moisture to cause the cuttings to become sticky or wet, but not enough to produce liquid flow at the surface. This type formation can quickly stick the drill string. The third type is a very wet formation which produces liquid at the surface almost at once when it is penetrated. There are a number of different methods of dealing with each of the three types.

How to detect moisture in the hole. This can often be done visually at the surface. Ordinarily, air drilling produces sizable percentage of cuttings small enough to be classified as dust. This dust is usually picked up by the wind at the end of the flow line. When this dust disappears from the returns (even though larger cuttings continue to return) chances are moisture has been encountered down the hole. Of course, if the liquid flow is strong, it may come right out the flow line along with the cuttings, removing any doubt as to the presence of down-hole liquids.

How to spot the exact location of liquid producing zones. The first step in devising a means of combating the liquids in the hole is to determine the point at which liquids are entering the hole. This is difficult. It is quite possible to drill 300 ft or so below the first entrance of liquids into the well bore. This means that it may be necessary to treat three or four hundred feet of hole to cure the aliment of 10 ft or so of hole.

Temperature recorder is effective. One means of recognizing the point at which moisture is first encountered is to mount a recording thermometer on the flow line. As liquids are picked up in the hole, evaporation reduces the temperature of the air flowing from the hole. This drop temperature correlated with changes in drilling rate is very effective as a means of marking the top of a moisture zone. When the top of the moisture zone has been determined, the question then becomes how far into the zone should one drill before some attempt is made to shut off the water flow. This will be dependent upon the type of water shut-off which is to be attempted.

Water in hard sand and lime formations. On wells that encounter fluids, you can often continue air drilling if surface equipment is of sufficient capacity and capable of high pressures. Wells that make fluid must be drilled with volumes of air 20 to 40 per cent above that required for dry drilling. Of course, the higher the volume of air circulated, the greater the friction and circulating pressure. This procedure works in drilling hard sand and lime formation. Should clays, shales or redbeds exist either above or in the fluid zone, it is doubtful that a straight air-drilled hole could be continued.

When mud is formed by air cuttings and water, one solution to this problem is slugging the annulus with small amounts of water. This is done by running the mud pump for periods of three to five minutes for the initial injections of water, or by running the mud pump until a top air pressure is reached and then shutting the mud pump down and allowing the air stream to circulate the hole with the water in suspension. This procedure breaks the heavy mud that has been formed by the water invasion and the cuttings from the formation drilled. It breaks this mud slurry back to a light mud that can be lifted by the air stream. *Once this type of drilling is started, it must be continued until a casing point is reached.*

After the first injection of water into the air stream, an "on and off" cycle of the mud pump will, in most cases, allow a penetration rate 80 per cent as good as straight air-drilled wells. You will note that in following this type of drilling, your circulating air pressures will build up some three to four times higher than that of dry drilling; then when the mud pump is shutdown, the pressure will fall back to somewhere slightly above that of the dry-drilling pressures.

Water flow near lost circulation zone.

FIG. 2 Equipment Requirements for Air Drilling

	Surface holes 12¼-in. to 17-in.	Under surface pipe to 5000 ft (dry) 7⅞-in. to 9-in. hole	Under surface pipe to 5000 ft (wet) 7⅞-in. to 9-in. hole	Under intermediate casing 2500 ft to 12,000 ft (dry) 7⅞-in. to 9-in. hole	Under intermediate casing (wet) 2500 ft to 12,000 ft 7⅞-in. to 9-in. hole	Coring Drilling in soft formation	Coring Drilling in hard formation	Aerated mud Fast penetration 6¾-in. to 9-in.	Aerated mud Lost circulation
Air volume	2500 cfm	1600 cfm	2100 cfm	1600 cfm	2100 cfm	800 to 1000 cfm	1000 to 1500 cfm	1500 to 2000 cfm	50 to 150 cfm per bbl of fluid circulated
Air pressure	0–125 psi	0–250 psi	0–800 psi	0–300 psi	0–1250 psi	650 psi	650 psi	500 to 1250 psi	300 to 1000 psi
Well head equipment	Cutting deflector (see drawing)	Double BOP Rotating head Float valve	Double BOP Rotating head Float valve	Double BOP rotating head Float valve	Double BOP Rotating head Float valve Bleed line	Double BOP Rotating head Bleed line	Double BOP Rotating head Bleed line	Double BOP Rotating head Float valve Bleed line	Double BOP Rotating head Float valve Bleed line
Manifold and flow line	7-in. flow line Bleed line	7-in. flow line Bleed line	7-in. flow line Bleed line	7-in. flow line Bleed line	7-in. flow line	4-in. flow line	4-in. flow line	7-in. flow line Mud-air separator	7-in. flow line Mud-air separator

In areas where no down-the-hole water will be encountered, straight air drilling provides an excellent solution to the problem. However, if there is a weak zone below a shale section with water flow above or below the zone, aerated mud may provide the best answer. A good mud capable of holding the shale up can be lightened to a controlled degree by varying the cfm of air per barrel of mud circulated. The effect is to hold the back water flow and at the same time prevent pumping into the weak zone. Lowering the hydrostatic head of the mud column to control this type of lost circulation is a hard problem to solve. It is mostly a trial and error operation until a balanced system is worked out.

Water shut-off service companies. At least two major oil well service companies are carrying on extensive research programs aimed at solving the problem of moisture in air-drilled holes. There have been some experimental successes in the field, but neither of these companies has a product or service available on a commercial basis. At least two smaller companies are working on water shut-off methods and have had some success in field applications. All of these companies are using some form of plastic or other chemical materials as a water shut-off device, and the method of application in each case is somewhat different.

The approach of one group is that conventional oil well servicing equipment will be called out and used to pump treating solutions into the hole below a packer. Another group is attempting to provide tools that can be left on the rig and run into the hole at the discretion of the tool pusher with rig equipment. An excellent article concerning experimental work done by one major company has been published in the October 1956 issue of THE PETROLEUM ENGINEER.

Testing a water shut-off job. After a water shut-off job has been accomplished, it is essential to determine how effective it has been. One good way is to drill out the zone which has been shut off or plugged, stopping just before reaching the maximum depth of the treatment and then circulate for a period of time to be certain that a water shut-off has been effective within the zone. If the test is successful, drilling can proceed, with the knowledge that if further moisture is encountered, it will come from a deeper zone.

The economics of water shut-off will determine how much of the water zones can be treated for continued drilling. This will be quite a difficult problem to decide on wildcat wells, but once an air-drilled hole has been completed in a given area, subsequent holes may be air drilled with some foreknowledge of the wet zones to be encountered and their extent. To date, interpretations of electric logs on wells that have been drilled with liquids have not been particularly helpful in spotting moist zones in holes to be drilled with air or gas. There is much to be done in this field of electric logging and log interpretation as a guide for water shut-off in air-drilled holes.

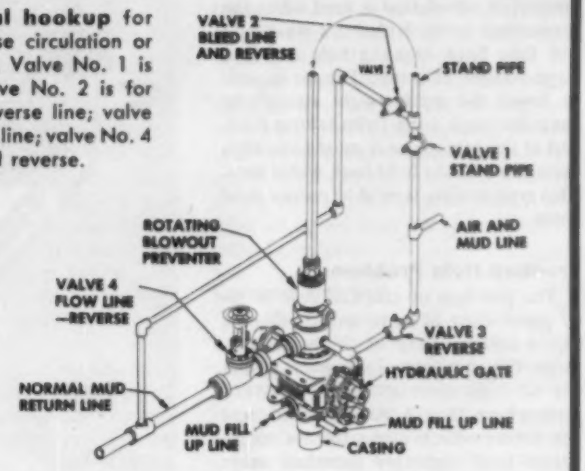


FIG. 3. **A typical hookup** for using either reverse circulation or normal circulation. Valve No. 1 is for standpipe; valve No. 2 is for bleed line and reverse line; valve No. 3 is for reverse line; valve No. 4 is for flow line and reverse.

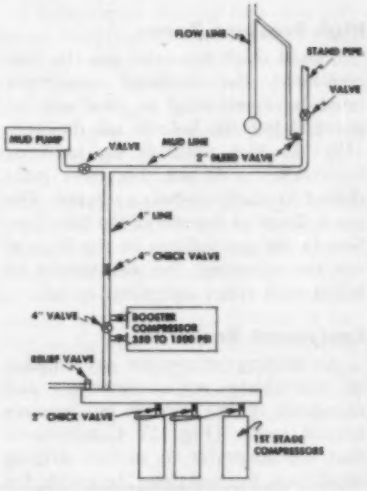


FIG. 4. **Schematic diagram** for compressor manifold.

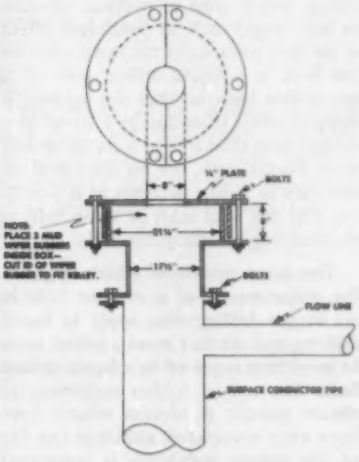


FIG. 5. **Cuttings deflector** for drilling surface hole.

Aerated Mud Drilling

Equipment requirements of aerated mud drilling differs from those of straight air drilling. Basically there are three classifications of this type circulation:

1. **Aerated mud — using a high volume of air and mud.** This method requires sufficient equipment to compress 1200 to 1800 cfm of air to pressures up to 1250 psi; and a mud pump capable of 100 to 300 gpm at equal pressure. Use this type circulation where it is not practical to case off water sands and the primary objective is to increase penetration rate. (In most cases, the increase in penetration rate runs 50 to 80 per cent above that of straight mud drilling.)

2. **Saturated air circulation (high-air volume — low mud volume).** This method is effective in combating water seeps in hard formations. It is not effective in clays or shales that tend to swell or slough. As a rule, 10 to 50 gpm of mud is used with 1200 to 1800 cfm of air.

3. **Balanced air-mud (50 to 100 cfm of air per bbl (42 gal) of fluid.)** This method of circulation is used when the formations being drilled are weak and will take fluid and the hole makes a large volume of water. The air is used to lower the mud weight enough to keep the weak zone from taking fluid, and at the same time it must have high enough weight to hold back water flow. This type drilling is used to reduce mud costs.

Crooked Hole Problems

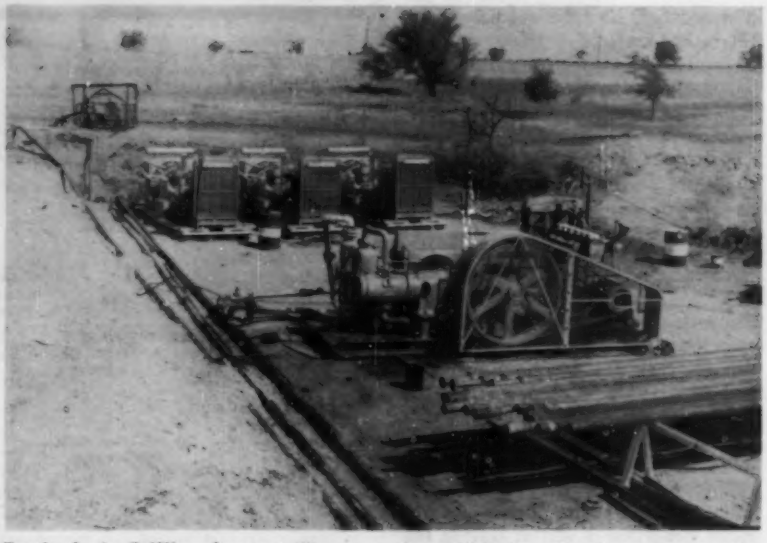
The problem of crooked hole in air or gas-drilling is more serious than in liquid-drilling, even in similar formations. One possible explanation is that the bit drills more effectively in a dry atmosphere than it does in mud, and the forces which cause the bit to increase hole angle are therefore more effective than they would be in a liquid hole.

On the other side of the picture, the forces which tend to prevent increase in hole angle such as pendulum effect of the drill collars, are the same whether the hole is a liquid-drilled hole or a gas-drilled hole, so that the balance is more difficult to obtain in a air-or gas-drilled hole than it is in a liquid-drilled hole. Fortunately, the bit does drill effectively at lighter weights in dry-drilling and this is at least of some help in maintaining a straighter hole.

The same principles which apply to the maintenance of a straight hole in air or gas-drilling also apply in liquid drilling, except that more caution must be used than required in a liquid-drilled hole. The use of rubber stabilizers to obtain greater pendulum effects have been very successful, although the life of the rubber stabilizers is somewhat shortened by operation in the dry atmosphere of an air-drilled hole. Short life is particularly noticeable as greater depths are obtained. This is generally thought to be caused by increased wear on the rubber stabilizer in making trips in and out of the dry hole.

As greater depths are obtained, increased temperatures are frequently observed in a dry-drilled hole, with the result that the rubber becomes soft and wears much more rapidly. The fact that there is no lubrication by liquids on the outer rubber surface also gives some explanation as to the increased rate of wear. In terms of feet of hole drilled, the rubber stabilizer may be expected to obtain approximately ½ the life of that expected in a mud-drilled hole.

Large collars have been used with fair success in air-drilled holes, but they are not as effective as they are in a liquid-drilled hole for the reason mentioned above.



Typical air drilling layout. There are three 500 cfm units that compress the air to 350 psi and one booster compressor that carries the pressure to 1500 psi.

High Pressure Zones

Should high-pressure gas be encountered, the wellhead equipment must be manifolded so mud can be pumped into the hole to kill the well. (Fig. 3) Gas volumes up to 8 or 9,000,000 cu ft per day have been drilled to reach oil-bearing zones. The gas is flared at the end of the flow line. Should the gas volume be too high to run the oil string, the well should be killed with either salt water or oil.

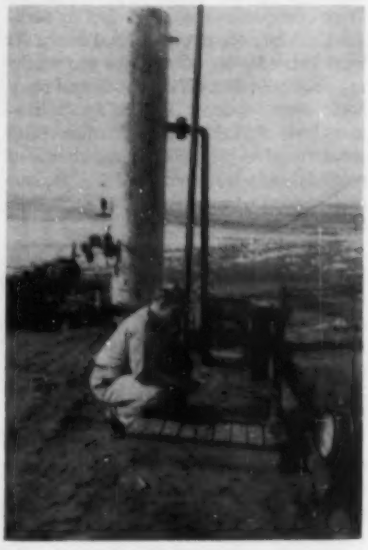
Equipment Required

Air drilling today is not just a matter of assembling air compressors and manifolds on the location but requires special tools. (Fig. 2) Compressors that are adaptable to surface drilling would not, in most cases, be usable for coring or drilling-in. Pressures and volumes are affected by depth of hole and hole size, and the size drilling tools that are in the hole. Also, the formation that is being penetrated is a very important factor in selecting the right size surface tools.

Fig. 2 shows approximately the volumes and pressures one would encounter for the particular drilling that is being done. The only factor not shown in Fig. 2 is that the temperature of the air must be low. This is most important. It has been found that rig equipment, rotary hose, and swivel packing will break down when air temperatures exceed 225F.

On wells being drilled below 7000 ft, bottomhole temperatures sometimes are high. When the drilling air temperature is also high, the additional heat from rotation friction of the drill collars in the dry hole is sufficient to make breaking out of the drill collars difficult.

How to get equipment. Here are the



Air separator for moisture and flow meter.

Dust separator on end of flow line.

four means of obtaining air drilling equipment in West Texas today:

(a) Air drilling service company,
(b) Rental,
(c) Lease,
(d) Purchase.

There are a number of air-drilling service companies in operation today. Their style of business is to furnish at a day-rate charge the compressors, manifolds, operating personnel, and the technical help needed for any air-drilling problem.

Some air compressor maufacturers have a plan whereby compressors are furnished only at a monthly rental rate per compressor. The operator furnishes the manifold and personnel, and usually the upkeep and maintenance of the compressor is at the operator's expense.

Another plan is a lease-purchase arrangement. This plan is similar to the rental plan as outlined above.

Operational Practices

Surface hole. In setting up for air drilling the surface hole, high-volume, low-pressure air is required. To deflect the cuttings that are being blown back to the surface, a dust deflector (Fig. 5) is used. This dust deflector keeps the cuttings from building up under the sub-structure. Rotary speeds, bit weight, and type of bit to be run are determined by the formation. Usually all the weight of the drill string is run on the bit. Rotary speed will change with the formation.

In drilling below the surface pipe, a more uniform program can be set up. Compressor requirements and manifolding are shown in Fig. 2, 3, and 4. It has been found that conventional bits give just as satisfactory performance as jet bits. In penetrating soft formations, high rotary speeds and bit weights of 15 to 25,000 lb get the best results. In hard formations, low rotary speeds (40 to 55 rpm) and a bit weight of 30 to 35,000 lb are advantageous.

In drilling below the intermediate pipe, the only problem that presents itself is drying the hole up before air drilling commences. When a long intermediate string of pipe is set, high-pressure air must be used to unload the water in the annulus. This is done by running the drill string of pipe to the bottom of the hole, starting circulation with the mud pump and then injecting a small volume of air into the mud line. Gradually increase the volume of air until the full volume of air required to dry drill is going into the mud column. After the air/mud has broken around, shutdown the mud pump and allow the air to unload the remaining water. Drying up a hole at 7000 ft usually takes approximately six to seven hours.

Drilling-in and coring. More and more wells today are using air as a means of drilling-in and coring. By using air, the pay zones are never damaged. Again, high-pressure air equipment must be on the well. Drilling-in and coring circulating pressures vary from 150 to 650 psi, depending on the depth and size hole. These pressures are also affected by the amount of fluid that bleeds into the hole. We have found that cool air must be circulated to prevent a diesel action when drilling-in or coring oil-bearing zones. High volumes of air are desirable on drilling-in and somewhat lower volumes of air are required for coring. The volume of air required for coring is determined by the formation that is to be cored. Soft or broken formation requires the very minimum of air due to air blasting the formation away from the core barrel. Coring time is usually four to five times faster with air than with mud.

Logging Problem

Conventional electric logs that rely on an electrical contact between a recording instrument and the wall of the hole, requiring the presence of the liquid in the hole as an electrolyte, are not usable in a dry-drilled hole. These logs, which by measuring the self potential and the resistivity of the formations, have been relied upon as a guide to possible productivity of a formation. Therefore, it becomes necessary to develop other means of logging in order to determine the porosity, formation content and percentage of fluid in the hole where these electric log techniques cannot be used. Radioactivity logs have been used with some success for this purpose in the San Juan Basin area. An excellent article describing this technique was presented in the October 1956 issue of THE PETROLEUM ENGINEER. This article was written by D. H. McLendon.

There have been numerous occasions in which an air-drilled hole has been filled with liquid upon completion in order that conventional electric logs could be run. In any event it is possible to log the hole, but the fact that it has been air drilled does present some difficulty in logging.

Current Practice

In West Texas, some drilling contractors are bidding on wells using either air or mud. By doing this, the contractor takes full responsibility for all outside costs for the use of the air-drilling services, but at the same time he can increase his profit by three to four times that of drilling the same section of hole with fluid. The majority of air-drilled wells in the Permian Basin have been on the basis of day work contracts with the drilling contractor, and the operator has furnished the air equipment and air-drilling service engineers.

The future of air drilling appears very good. The equipment manufacturers are now designing and building compressors that will meet the needs of air drilling volumes and pressures. The API and AAODC have set up a joint committee to study and make a report on all phases of air drilling. The savings effected by the use of this medium are so great that the problems encountered now must be solved so that the benefits of air drilling will be universal to hard rock drilling. ★ ★ ★

Gulf Coast AIME, Directory, Formation Evaluation Book Published

Two new publications recently released are now on the market by the Gulf Coast Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

The Gulf Coast Section has completed publication of its Directory of Members, dated June, 1956. The compilation lists members both alphabetically and by company affiliation. The 115-page book is furnished gratis to Gulf Coast AIME members, with a limited number of copies available to non-members for $1.00 per copy. This publication also lists present officers and committees of the Gulf Coast Section, national AIME officers, officers and staff of the Petroleum Branch AIME, the by-laws of the local section, and past officers of the local section.

Original 2000 copies of the Formation Evaluation Symposium compilation has been exhausted and a second printing of 500 copies has been completed. These are now available at $5.00 per copy, through H. M. Krause, Humble Oil & Refining Company, P. O. Box 2180, Houston, Texas.

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SWAB *and* TEST

as many intervals as required

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After the Retrievable Bridge Plug has been run to the desired depth and released, it will automatically set and pack off against pressure differentials established from either above or below the tool.

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Used BY ITSELF for:

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(c) Temporary pressure containment to permit repair to or removal of well head equipment with safety.

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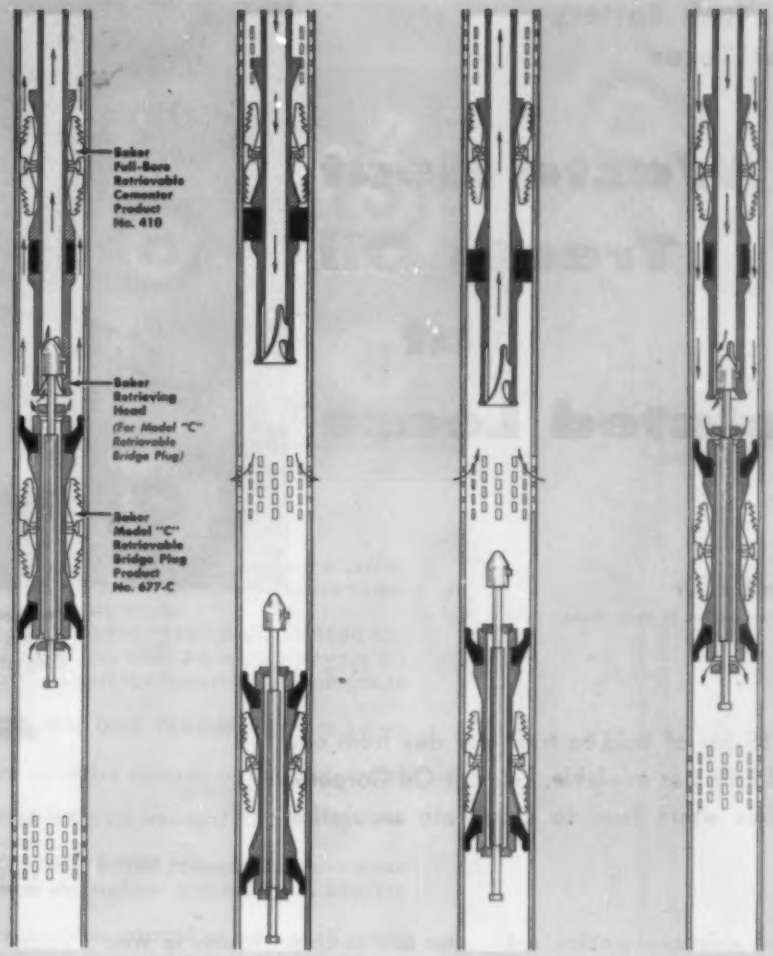
Baker Full-Bore Retrievable Cementer Product No. 410
Baker Retrieving Head (For Model "C" Retrievable Bridge Plug)
Baker Model "C" Retrievable Bridge Plug Product No. 677-C

RUNNING-IN
Retrievable Bridge Plug being run into well on bottom of Full-Bore Cementer through use of Retrieving Head. Note fluid by-pass.

FRACTURING OR ACIDIZING
Plug should be pressure tested after release. Cementer is released, raised above perforations and reset for pressure operations.

SWABBING, TESTING
Note how the reversal of pressure differential has transferred load from one set of slips to the other (both cementer and plug).

RETRIEVING
Plug and Cementer being moved to next set of perforations—or retrieved from well. Valves in plug open to permit fluid by-pass.

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HOLDS PRESSURE FROM EITHER ABOVE OR BELOW

Two sets of opposed slips enable the cementer to hold pressure from either above or below. Casing can be tested before squeeze—and the tubing also, if the Baker Full-Bore Tubing Tester is used.

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Permits Passage of Tubing Perforators or Instruments—Assists in Preventing "Screen-Out" on Fracturing Jobs

The Full Bore through the Cementer (and Tester if used) is in reality a continuation of the bore through the tubing.

This continuous full ID passage not only permits passage of tubing perforators or instruments but assists in preventing "Screen-Out" (sand dropping out of the oil) and subsequent plugging of the tubing in fracturing jobs.

IDEAL STRADDLE TOOL WHEN USED WITH BAKER RETRIEVABLE BRIDGE PLUG

The operation of the Cementer setting mechanism makes it easy (through the use of the Retrievable Bridge Plug Retrieving Head) to release and pick-up the Baker Retrievable Bridge Plug. It is in fact the ideal partner to the Retrievable Bridge Plug for selective multiple-zone or single-zone operations.

these products and their application

BAKER OIL TOOLS, INC.
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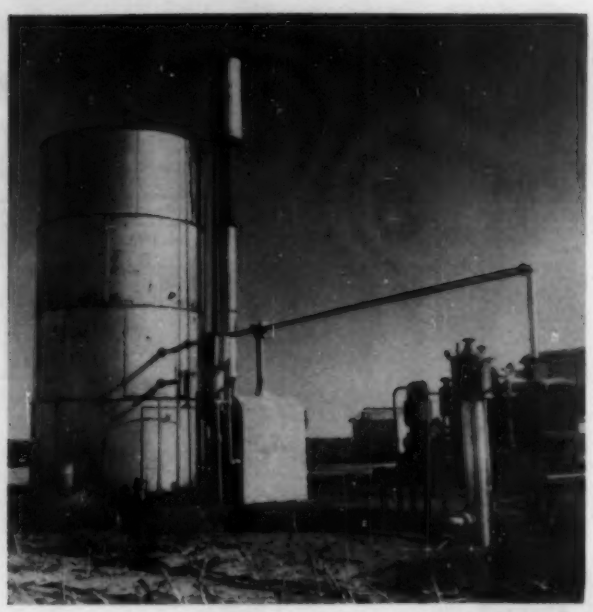
Unique Tank Battery in West Texas

Waste Heat Treats Oil at Isolated Lease



Felmont's waste heat system installed on a tank battery in the Felmac field of Gaines County in West Texas.

Peck Hardee, Jr.
Felmont Oil Corporation, Midland, Texas

With 2765 bbl of fluid to treat per day from one well, and little gas available, Felmont Oil Corporation utilizes waste heat to accelerate separation

A difficult separation problem and a deep, high-volume producing well combined to make an interesting and unique production operation. Large volumes of fluid with very little gas are produced. The well hydraulically pumps 1500 bbl of water, 150 bbl of oil, and 1115 bbl of power oil each day. The gas-oil ratio is only 14 cu ft per bbl, which is not enough to fire a heater to accelerate separation of water, much less provide fuel to power the engine driving the power oil triplex pump.

Every available source of heat produced at the tank battery is utilized in producing steam to heat the fluid content of a gun-barrel tank. Waste engine exhaust heat, steam from a small boiler fired by the small volume of gas produced, and heat obtained in generating steam in the pump engine cooling system is piped to coils in the gun barrel. As a result, pipe line oil comes out of the gun barrel at 0.1 per cent bs&w. When the ambient temperature was approximately 55F, temperature of fluid inside the gun barrel was 108F.

This unusual engineering problem arose when Felmont Oil Corporation of Midland, Texas, discovered the Felmac field in Gaines County in West Texas in September, 1955. The well is located on a 160-acre lease and produces from the Mississippian from 13,020 to 13,058 ft. The well was originally completed water-free and produced 8000 bbl of clean oil before a water-cut was noted. Water increased to 65 per cent within five months after discovery and leveled off at this water-cut. However, total fluid recovery decreased to 78 bbl of oil and 147 bbl of water from its peak monthly production rate of 334 bbl of oil and 88 bbl of water per day five months previously. At this point, it was decided to install hydraulic lift equipment. A casing type power pump to conventional installation was used to eliminate the production tubing. Exhausted power oil was returned to the surface with produced fluid in the annulus between the power oil tubing and the casing. A 4-in. by 2⅜-in. production unit was run. It has a pump displacement of 1850 bbl per day at 57 strokes per minute. A schematic diagram in Fig. 1 shows this pump set at 5000 ft. The maximum setting depth for this size and type of hydraulic pump is 6500 ft.

The production unit is presently op-

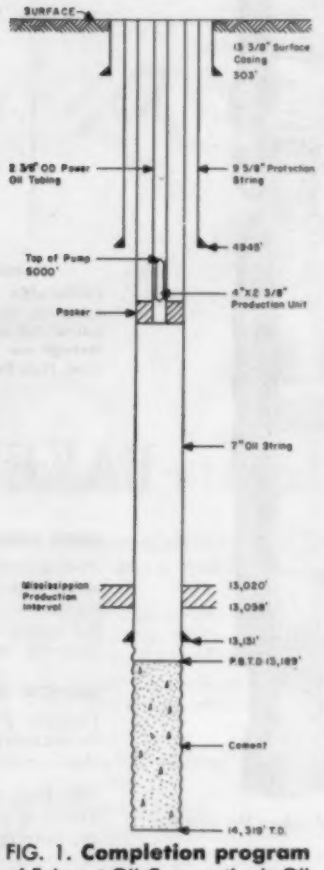
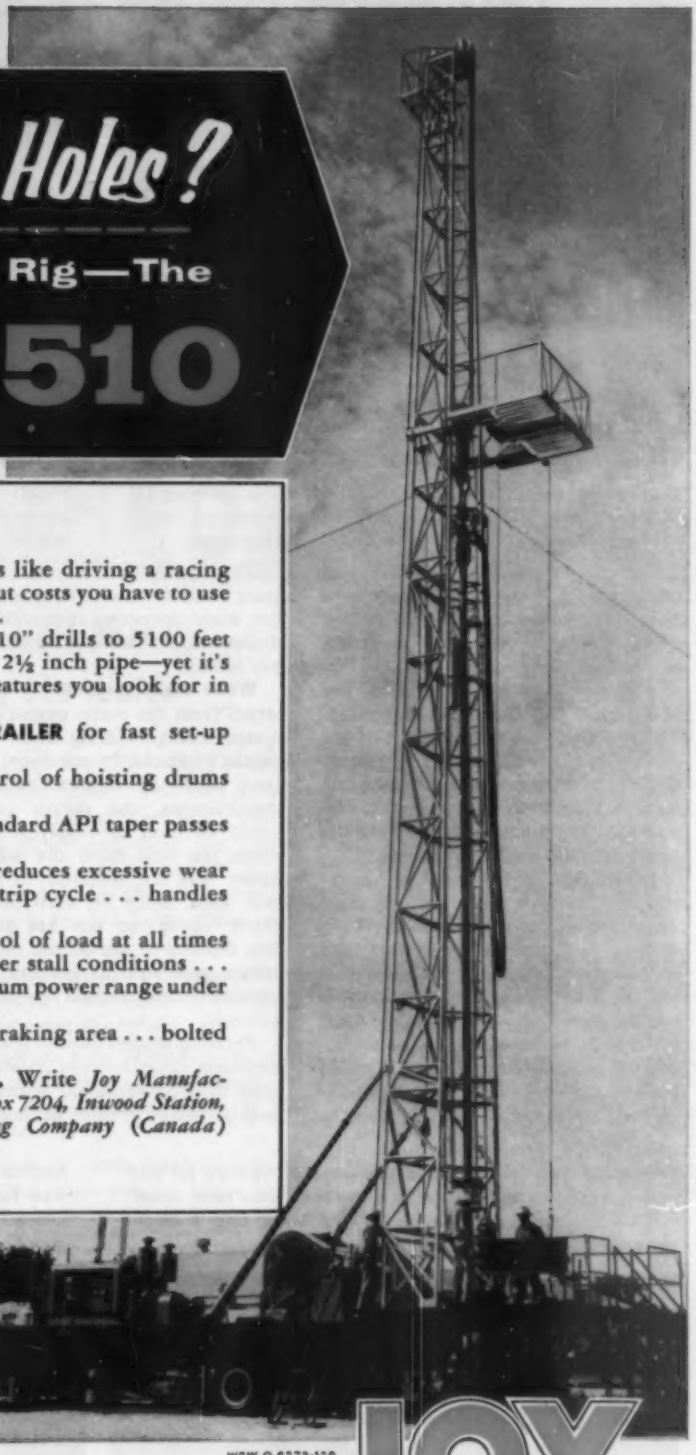


FIG. 1. **Completion program** of Felmont Oil Corporation's Oil Development No. 1 in the Felmac field of Gaines County, Texas.

Drilling Slim Holes?

Use a Slim Hole Rig—The

JOY 510



Drilling Contractors:

Drilling slim holes with a conventional rig is like driving a racing car at tractor speeds—it's wasteful. To really cut costs you have to use a rig specifically designed for slim hole work.

Here's that rig—the Joy "510." The Joy "510" drills to 5100 feet with 3½ inch drill pipe . . . 10,000 feet with 2½ inch pipe—yet it's completely portable. The "510" has *all* the features you look for in a rig:

ENTIRE DRILL UNIT MOUNTED ON ONE TRAILER for fast set-up and tear-down

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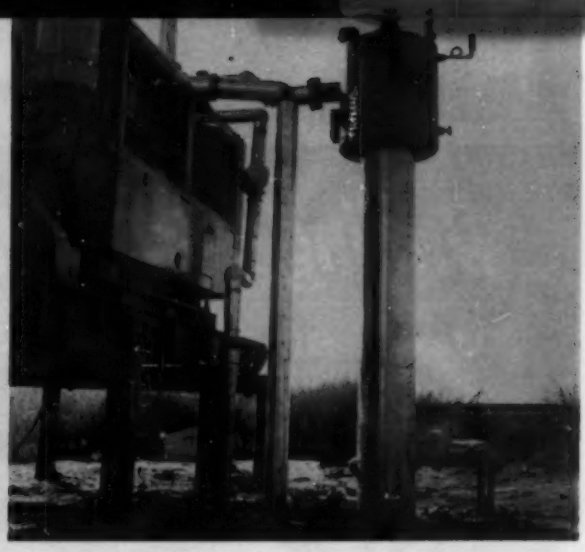
Heat sources to treat 2765 bbl fluid daily come from (1) high temperature engine cooling, (2) engine exhaust waste heat boiler, and (3) steam generator in background.



Waste heat boiler at right takes exhaust at bottom from diesel engine, hot water from mud leg of steam generator and discharges steam into surge chamber.

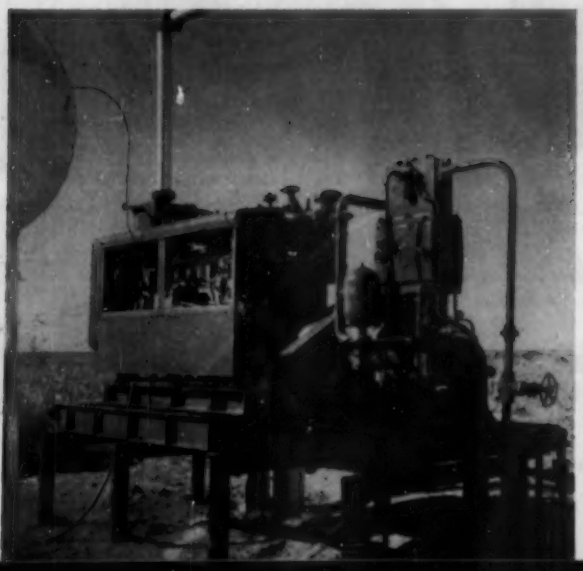
erating at 52 strokes per minute at a power oil pressure of 2200 psig. At this speed, the pump produces 1650 bbl of fluid per day and requires 1115 bbl of power oil. This is a total of 2765 bbl of fluid per day that must be treated. The well produces only 14 cu ft of gas per bbl of oil or 2240 cu ft of gas per day. Since the lease was an isolated one and fuel gas was not available, the problem of economically treating the produced fluid was a critical one.

Initial plan. It was found in reviewing cost data that there was very little difference in operating cost between the use of butane or diesel fuel, and conservative estimates indicated that fuel costs to operate the pump engine and the steam generator would be $900 per month. Initial savings were visualized by utilizing a diesel oil engine and a diesel oil burner in the steam generator and eventually switching over to lease crude for fuel. The steam generator, when operating at maximum conditions, would cost approximately $600 per month.

Waste heat captured. By capturing steam from the pump engine's cooling system and generating steam with the engine's exhaust by means of a waste heat boiler to supplement the heat requirements, the steam generator could be used to supply steam only when the heat from the waste heat boiler was not sufficient to treat the well fluid. Since the total Btu output from the engine was not known, it was decided to use butane only in the steam generator to get the plant in operation and reduce its use when possible.

Previous studies showed that indirect emulsion steam treaters consumed less fluid than conventional heater-treaters and permitted greater flexibility for a unit of this type. This system had the second advantage of permitting its use in conjunction with exhaust heat and high engine cooling water temperatures to generate steam for use in treating crude oil emulsions. It is common knowledge that 1 lb of water raised 1F absorbs 1 Btu. However, when 1 lb of water is raised from the boiling point (212F at sea level) to one degree higher (213F at sea level), it absorbs 970 Btu. When transferred from steam to water, it releases the same amount of heat. This terrific heat change with only 1F temperature change is known as latent heat and is the principle behind the indirect emulsion steam treater. In fact, it is possible under controlled conditions to complete this entire cycle with very little visible change in temperature. During this cycle, 1 gal of water performs the same function as 121 gal do below this critical point

Triplex pump and 75-hp diesel engine mounted on skid and elevated so water level in surge tank (box near radiator) will be at same level in waste heat boiler and in steam generator.



Author Peck Hardee, left, and G. G. Green, field foreman for Felmont Oil Corporation, stand along side insulated engine exhaust waste heat boiler. Note gage glass in boiler section. Steam is carried off in line at right.

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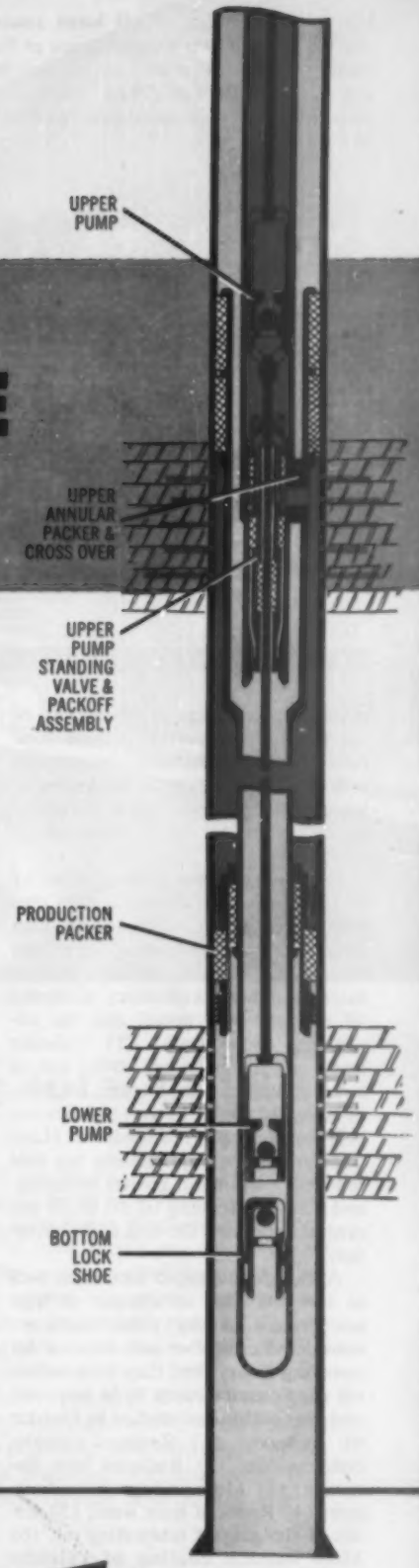

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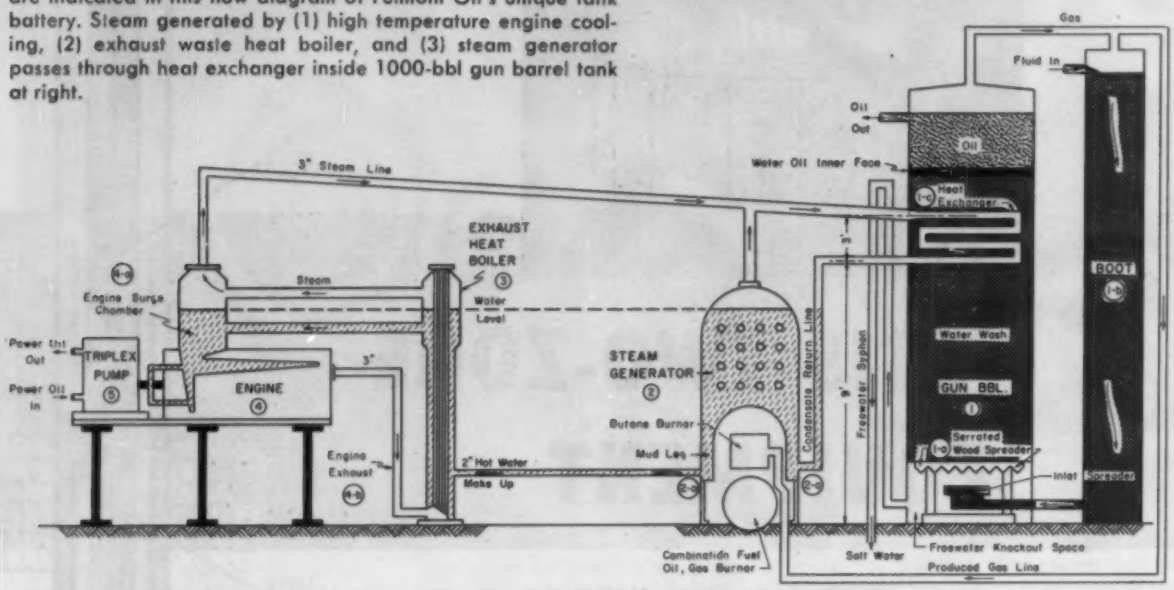
FIG. 2. **Utilization of all heat sources** to treat well fluids are indicated in this flow diagram of Felmont Oil's unique tank battery. Steam generated by (1) high temperature engine cooling, (2) exhaust waste heat boiler, and (3) steam generator passes through heat exchanger inside 1000-bbl gun barrel tank at right.



permitting re-design of all factors of any system in proportion to these same ratios. To gain maximum advantage of a system of this type, a minimum of temperature change from water to steam is necessary in the engine jacket water.

High temperature cooling. Tests by O. B. Freeman of Tidewater Oil Company, Ventura, California, of high temperature engine cooling were most helpful. These tests[1] indicated that an increase in thermal efficiency of around 40 per cent was noted, and the advantages found were: (1) Cylinder liners and cylinders are cooler and at a more uniform temperature, resulting in increased engine power; (2) Greater heat-transfer rates are obtained. Heat-transfer surface requirements are thus reduced, resulting in greater economy; and (3) Overloading of 10 to 20 per cent may be used for safe daily operation.

Although the above factors as well as the following advantages of high temperature cooling systems were not considered critical in our decision for installing this system, they have sufficient supplemental merit to be included, and are conclusions reached by Gordon M. Jackson:[2] (1) Reduced cylinder condensation; (2) Reduced liner distortion; (3) More uniform liner diameter; (4) Reduced liner wear; (5) Reduced sludging of lubricating oil; (6) More uniform cooling of cylinder heads; (7) Uniformity of jacket temperature in spite of wide change in load or ambient temperature; (8) Simplicity of control and instrumentation; (9) Elimination of circulating pump — first cost and maintenance expense; (10) Reduction in auxiliary power consumption (fan); and (11) Reduction in installed cost of cooling system (radiator).

Other extensive work had also been carried out in California in operating engines at elevated (212F) temperatures and these studies indicated this method of cooling had many advantages with regard to engine maintenance. Use had also been made of this boiling point cooling to permit using fuels with high sulfur content. However, in most of these previous installations, engine heat was dissipated through heat exchangers to the atmosphere. It was decided, therefore, to generate steam with exhaust gases from the engine and operate the water cooling system at the boiling point, using this waste heat to directly treat oilfield emulsions from this lease.

Treater hookup. To assure maximum water wash and reduce heating of free water to a minimum, the heat exchanger (1-c) of flow diagram in Fig. 2 was located 10 ft above the bottom of the wash tank (1). To increase free water knockout, a serrated spreader was placed 4 ft above bottom in the water wash section.

The 16-ft diameter tank gave 200 sq ft of water-oil inner face which is four times the surface of an 8-ft diameter treater. A fourth ring was added to the existing 750-bbl three ring tank to give a total of 12½ hours settling time. A small separator (1-b) in the top of the boot is held at 1 psi pressure and tied into the pilot and butane burner to capture all the available gas produced. A waste heat boiler (3) was then installed and the engine exhaust (4-b) was tied into it to recover this waste heat.

A surge chamber (4-a) replaced the conventional radiator to assure sufficient water volume to the engine. All of these lines were connected into the steam line leading to the heat exchanger (1-c) in the wash tank (1). This system permitted recovery of heat from exhaust gases, engine radiator and from gas recovered from production. To supplement this, the butane burner was still available to assure proper gun-barrel temperatures regardless of recovered heat. At least ½ in. of fiberglass insulation covered by aluminum sheeting was placed on all pipe and fittings to reduce radiation and heat losses to a minimum.

The Author

Peck Hardee, Jr., is area engineer for Felmont Oil Corporation's western area. He was graduated from A&M College of Texas with a BS degree in petroleum engineering. During World War II, he served as an anti-aircraft officer in the Aleutian Islands. After release from service in 1945, he came to Odessa, Texas, and roughnecked for Rowan Drilling Company and joined Shell Oil Company in 1946 as an engineer assistant. In 1948, he was made district engineer for Texas Pacific Coal and Oil Company's Odessa district, and promoted to division engineer of Texas Pacific's West Texas division in 1950. He joined Felmont in November, 1953. He is a member of the AIME and is a registered professional engineer in the State of Texas.

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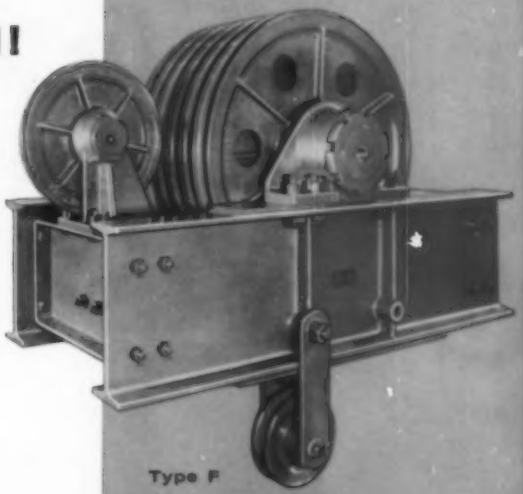
NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT



Type F
CROWN BLOCK

Rated at 525 tons, this is the largest of two Type F Crown Blocks available for deep drilling. The smaller unit is rated at 360 tons. Both blocks are of minimum width, have relatively short shafts and a correspondingly high strength to weight ratio. When necessary, they are easily dismantled in the field for installation.

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Match a compact National Type N Swivel with your National Block and you have a smooth derrick equipment "team" that's tough to beat! Here are the reasons why National Type N Swivels give you continuous service at low operating and maintenance costs:

1. **Reduced weight.** Complete redesigning has been employed to bring every model down to minimum weight in relation to individual rated capacity. The use of high quality, high-strength components throughout has reduced both over-all height and weight to greatly facilitate handling.
2. **Lower center of gravity.** Centerline of the bail pins on Type N Swivels has been raised, thereby lowering center of gravity. This means greater stability in handling, makes connection of swivel "sub" to kelly easier and faster.
3. **Streamlined exterior.** The one-piece steel body is free from any dangerous projections. All bolts, nuts, pins and grease fittings are recessed to assure maximum safety to the derrick crew.
4. **Fast wash pipe replacement.** National's exclusive Uniflex Wash Pipe Box assembly is standard on all Type N Swivels. An improved method for packing off the mud, the Uniflex assembly has quick-acting threads to speed replacement, is easily assembled by one man, can be installed without removing the gooseneck or breaking the hose connection.
5. **Rapid hose coupling.** Also standard on all Type N Swivels is the Quick-Seal Hose Connection that speeds make-up of hose joints. Besides eliminating one hose connection member and therefore minimizing the chance of mud leakage, the Quick-Seal Connection features larger, quick-acting threads and sealing elements to withstand rugged use.

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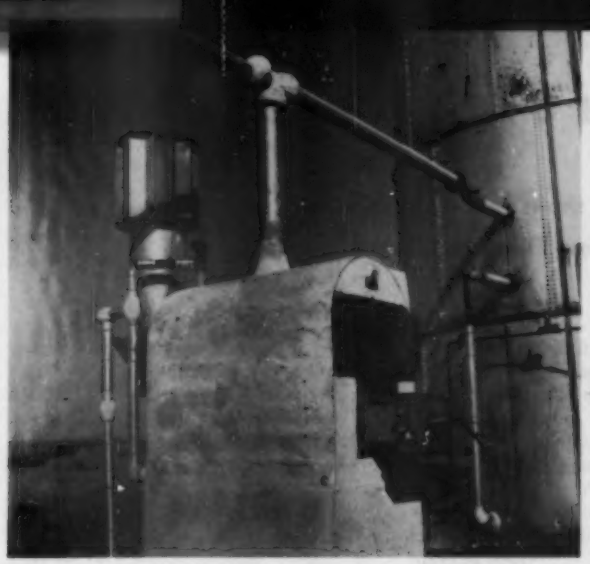
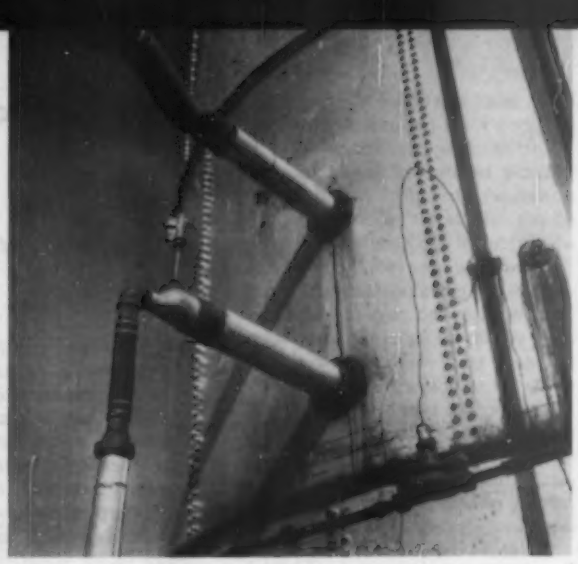
SPANG STEEL PIPE AND ELECTRICAL CONDUIT



Steam generator, with a rated capacity of 720,000 Btu per hr burns available gas taken from boot of gun barrel. Unit is equipped to burn butane from storage tank.



Heat exchanger connections into 1000-bbl gun barrel tank. Four-inch line at top conducts steam to coils inside tank while condensate returns through line at bottom.

The steam generator (2) was elevated 40 in. to permit future installation of an oil burner if required. Consideration is also being given to the use of a crude oil burner. A conventional butane burner was installed to assure a continuous source of heat since the first requirement of this treating unit was that production could not be interrupted under any circumstances while this development work was being carried out.

How system works. By referring to the flow diagram, condensate from the heat exchanger (1-c) in the gun barrel (1) flows into one of the mud legs of the boiler (2). As it passes through the boiler, it is heated up to the boiling point by produced gas from the boot (1-b). Any steam generated at this point moves through the steam line to the heat exchanger (1-c) in the gun barrel (1). Water flowing out of the opposite mud leg (2-a) enters the waste heat boiler (3) where it absorbs the exhaust heat (4-b) which further generates steam. The pre-heated water from the boiler also enters the surge chamber (4-a) mounted on top of the engine (4) and steam generated is collected for transfer to the wash tank heat exchanger (1-c).

Steam generator controls. Butane to the boiler burner is controlled by means of a thermostat in the gun barrel. When heat generated by the remainder of the system is not sufficient to maintain treating temperatures, the butane burner comes into operation, always assuring that the treating cycle is maintained.

A safety shut-down valve, actuated by the pilot, was installed in the butane line to shut off when the pilot failure occurred. A low water shut off was installed in the system to protect it in case of water loss. Pressure controls set at 1 psi were tied into the system for protection from excessive steam generation beyond the wash tank heat exchanger capacity. Pop valves were installed at the boiler and exhaust heat exchanger set for 10 psi. A thermostat was installed in the engine block just below the low water level in the surge chamber and set for 214F. Tests indicated that engine shut down was immediate when the water level dropped below this thermostat element.

Heat tests. Heat balance tests on the system were carried out using no butane for firing over a period of time sufficiently long to assure that all heat generated was gathered from the auxiliary equipment. Although tests on individual units were impossible, total heat generated amounted to 450,000 Btu per hr for the steam generator, exhaust heat exchanger and engine high temperature cooling system. The total heat input of butane consumption during the initial two months amounted in general to this same heat input as generated by the auxiliary equipment which means that previous butane requirements have been entirely eliminated. Temperature of the lubricating oil was reduced to 170F and the engine block could be touched with the hand without burning which indicates a temperature similar to that of the lubricating oil.

Exposed Christmas tree of producing well shows power oil line connected into tubing. Produced fluids, including 1115 bbl of power oil, flow through casing-tubing annulus.

Initial design. Initial design included facilities to include step thermostat control beyond heat generated by the engine itself. They include thermostat connections to remove heat generated by the produced gas, fuel oil or crude oil burners, and finally butane firing. Although all engine heat must be dissipated, it can be absorbed in the crude oil or water produced by varying the height of the water syphon, and the other heat mediums can be used as required.

Heat from formation. A final heat source to be utilized will be formation temperature. Present heat balance tests indicate that temperature of fluid from the well is 110F. Radiation losses of the power oil tank were such that 200,000 Btu are indicated as a minimum being carried off by radiation. Since two tanks are involved, this loss should be considered twice as much. By reducing power oil temperatures to a minimum, injection can be made at 100F permitting a 10F rise of the total fluid in the well which will improve the overall heat transfer rate of the system less butane firing of at least 200,000 Btu per

hour. Since the entire treating unit was designed for a net heat requirement of 1,000,000 Btu per hour, it has been possible by use of those elements in power, seldom before considered, to do 65 per cent of the work the initial unit was intended to do without their help.

Lease crude for fuel. Since operating engines at elevated temperatures has been used in the past to permit using high sulfur or sour gas with success, the next step will be to use existing crude oil to power the engine that will further reduce fuel lifting costs. A final step, if additional heat is required during the winter months, is to install a crude oil burner in the boiler that will further reduce the cost of treating below those already established.

What are costs? In utilizing the waste heat from the engine exhaust and from the engine's cooling system, an added cost of $2000 over a conventional treating plant was required. From cost data obtained to date, a saving of $200 per month was realized in cost of butane during the summer months operation. This saving was determined from two months operation during July and August prior to the installation of the waste heat boiler. The steam generating unit was fired with butane during this period.

TABLE 1. Operating Costs.

Month	Oil prod. bbl	Butane		Diesel fuel	
		Total cost	Cost/ bbl	Total cost	Cost/ bbl
July.....	4422	$204.85	$.046	$171.08	$.039
August.....	5041	219.08	.043	223.47	.044
Sept.....	5003	10.68	.002	294.19	.059

Table 1 shows fuel operating costs for the past three months. Butane costs were eliminated during the month of September. Utilizing the well's gas from the top of the gas boot on the gun barrel to burn the pilot on the steam generator further reduced the cost of butane.

This is one of the first installations of its type and offers considerable application in other areas where fuel gas is not available or where its cost is prohibitive.

References

1. Freeman, O. B., Tidewater Oil Company, Ventura, California, paper presented at California Natural Gas Association, Los Angeles Chapter, January, 1953.
2. Jackson, Gordon M., Drayer-Hanson, Inc., paper presented at Twenty-eighth Annual Fall Meeting, California Natural Gas Association, and published in *The Petroleum Engineer*, July, 1954, pg. D-32.

Acknowledgment

Assistance in the preparation of the steam treating portion of this report and in the installation of the treating plant was given by S. L. Stentz, president, Stentz Equipment Company, Midland, Texas, and G. G. Green, foreman, Felmont Oil Corporation, Seminole, Texas. ★ ★ ★

Improved Unit Aids Paraffin Control

Hot oil truck shows extreme versatility in "dissolving" West Texas production problem

CLEANING paraffin from flow lines and treating oil has long been a production problem in the Denver City, Texas, area in the Permian Basin. A number of methods including the use of chemicals, running steel balls and scrapers through the tubing and high pressure steam have been used. A new portable service unit designed to inject hot oil or water in dissolving paraffin and other deposits in the tubing and lines has been built by Willard L. Kidd of Denver City. Provided with high pressure injection pumps and a heater that burns crude oil right from the well, the unit is versatile and is now being used to kill wells with oil for workover operations as well as cleaning tubing, flow lines, and storage tanks.

At an injection rate of 70 bbl of oil per hour oil is heated to 275 deg or can be heated to higher temperatures of 450 deg with lower pumping rates.

The portable rig, mounted on a six-ton truck, is equipped with a high pressure triplex oil pump that will supply hot oil at pressures up to 5000 psi. This is powered by the truck motor through a variable speed power take off. An oil pump on the hot oil heater supplies a positive suction head at the triplex pump.

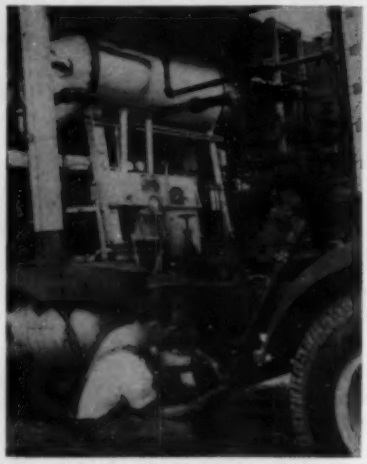
Unit is equipped with a transfer pump that will transfer 240 bbl an hour to, through and from a 60 bbl tank mounted on the truck. Tank serves as a reservoir for heating oil to higher temperatures by recirculating the oil through the heater. It also serves as a reservoir for crude oil to be used in the treatment and as fuel for the heater. This tank is empty as the rig goes onto a lease and also empty when leaving as is required by regulations.

All the controls and valves for regulating the power to the pumps, directional flow of the oil, and hot oil heater are mounted in one central area within easy reach of a man standing along side of the unit. One man can handle most of the jobs the rig goes out on.

Field use of this unit has shown that it takes on an average about one-half to an hour to clean out paraffin plugged lines. The hot oil heater pump develops pressures up to 200 psi, when high pressures are needed the triplex pump is used.

Typical procedure for cleaning a well with 1200 psi casing pressure is as follows: First, 10 to 20 bbl of cold oil are pumped into the well casing at 1250 to 4000 lb pressure to break through the plugged paraffin and kill the well. Next, 30 to 40 bbl of 400 deg hot oil are circulated down the casing and up through the tubing to clean out paraffin. Normally 50 to 100 bbl of oil are circulated to completely clean the tubing.

If the well is making salt, hot water is used instead of hot oil.



— *Photo courtesy Vapor Heating Corporation.*

Unit can heat the oil from the well to 450 deg and then circulate 70 bbl of oil per hour at 200 lb pressure.

— *Photo courtesy Vapor Heating Corporation.*

Piping up to well to pump hot oil into the well casing. It takes 50 to 100 bbl of oil, circulated through the casing, to clean tubing.

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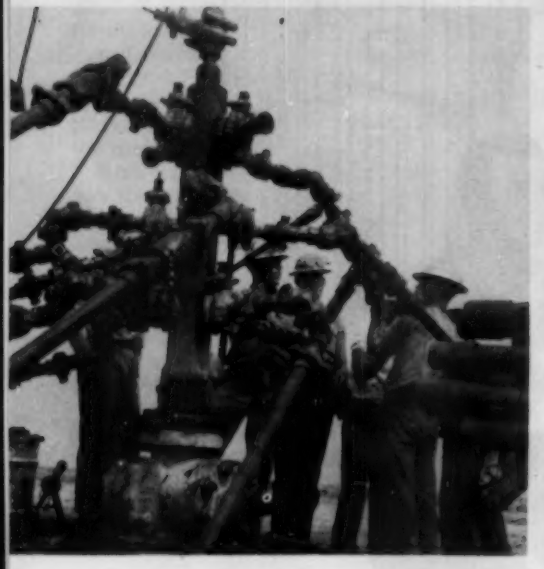
FIG. 1. **World's record fracture treatment.** Shown here is only part of the equipment used to inject 250,000 gal of fresh water and 200,000 lb of sand into a Spraberry formation well near Midland, Texas.

FIG. 1a. **Multiple wellhead conections** are required for the high injection rates used in fresh water frac treatments. Connections above given final check before a large-volume fresh water frac job.



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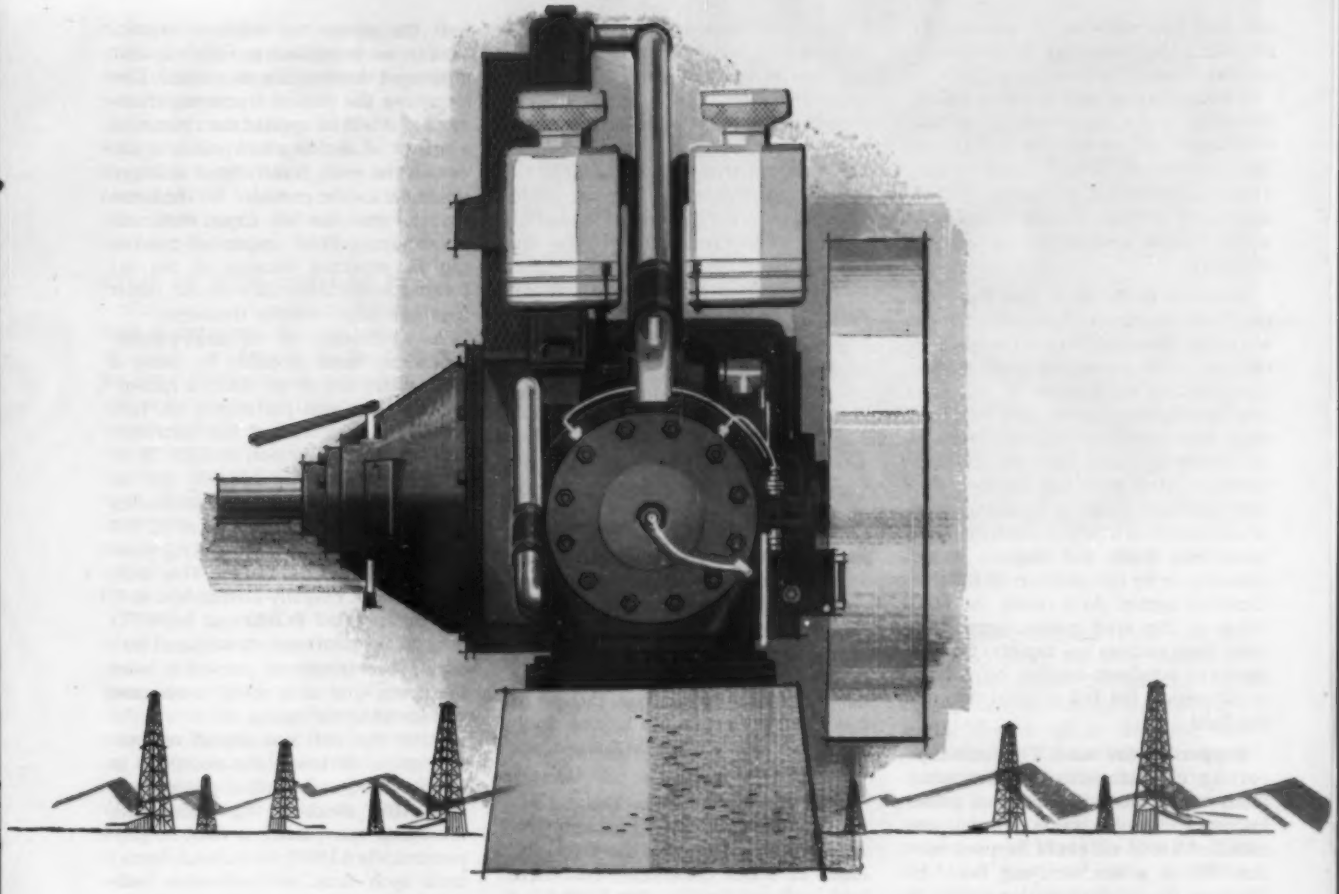
EXCLUSIVE

A brand-new concept in hydraulic fracturing, first used successfully a year ago on gas wells in the San Juan Basin by El Paso Natural Gas Company,[1] is finding widespread application in stimulating oil wells in the Permian Basin of West Texas and Southeast New Mexico. This radical departure from established procedures employs plain fresh water instead of the accepted viscous liquids as the fracturing fluid. Over 100 wells have been treated utilizing this new concept at greatly reduced costs.[2] It appears that about 80 per cent of these treatments will not only pay out, but will return a substantial profit as well.

Considerable study indicates that these greater stimulation increases by using unthickened fresh water are influenced to a large degree by the salt content of the formation rock, of the reservoir oil, and of the formation water. Three predominant factors contribute to a reasonable explanation of the improved fracturing results when fresh water is employed: in addition to creating a fracture pattern, it cleans the fractured surface and increases the effective permeability of the rock by dissolving salt in the matrix, thereby enlarging the individual flow channels.

Essentially this new technique involves a fracture-type treatment in which a slurry of sand suspended in fluid is injected into a producing formation under high pressure to increase the effective permeability of the forma-



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tion and thus stimulate production. In this case, the fracturing fluid consists of unthickened, fresh water.

This technique appropriately called Riverfrac is an outgrowth of earlier treatments in which the fracturing fluid consisted of thickened water (water containing suitable gelling agents, to provide increased viscosity and improved sand-supporting characteristics).

Function of fluids. A frac fluid has two basic functions: First, to transmit hydraulic pressure from the surface to the face of the formation, forcing open fractures and weaknesses in the rock, and holding them open until they are filled with sand; and second, to carry the propping sand into the induced fractures. Any fluid will perform the first function; however, keeping sand in suspension in a fluid is more difficult. Most frac fluids are viscous, either naturally or by the addition of suitable chemical agents. As a result, the fluid clings to the sand grains, preventing them from settling out rapidly. Gelling agents or emulsion droplets often physically retard the fall of sand through the fluid.

Supporting the sand. The sand-supporting characteristics of fracturing fluids were considered to be of prime importance until it was found that unmodified crude oil could be used successfully as a sand-carrying fluid. In this case, the sand-supporting ability of the oil was practically nil. However, by using high injection rates, it was found that the velocity of the fluid was sufficient to keep sand suspended in the oil until after it entered the formation.

Similarly, by employing injection rates in excess of 30 bbl per min down casing, or above 5 bbl per min down 2-in. tubing, it has been possible to use unthickened water as a fracturing fluid, without screen-outs of the sand.

Reduced fracturing costs. Naturally, the principal advantage of fresh water fracturing is its economy. By using fresh water instead of more expensive fracturing fluids, it has been possible to cut the overall cost of fracturing treatments materially. Comparative cost figures for different types of fracture treatments are shown in Table 1.

TABLE 1. Estimated Cost of 100,000 Gal Fracturing Treatments in Permian Basin

Fracturing Fluid	Average Cost
Acid gels	$36,000
Residual oils	17,000
Thickened lease oils	11,000
Unthickened fresh water	7,000

Note: Figures based on sufficient pumping equipment to inject at rate of 30 bbl per min with surface pressure of 5000 psi.

Where fresh water is readily available, such as in a nearby river or pond, it can be pumped directly from the source into the well. In much of the Permian Basin area, however, fresh water is not always at hand. In such cases, storage tanks must be hauled to the well site and set up, and the water for the fracturing treatments hauled in by truck. This procedure increases the cost of the treatment, but in no case is it as costly as using refined oils or other specialized fracturing fluids.

Fire hazard reduced. When lease crudes are available, it may seem to be cheaper to use them rather than water. However, the added danger of fire when flammable liquids are pumped makes the value of such an economy questionable. Several disastrous fires have occurred in the Permian Basin because treating lines or connections sprung leaks, spraying volatile crude oil on hot engine mufflers or exhaust pipes.

Recent modifications of pump truck design have greatly reduced fire hazards, although the use of lease oil as a fracturing fluid always presents some danger of fire. By contrast, the use of fresh water offers no fire hazard. Spillage or accidental leaks do not produce a dangerous condition.

New storage methods. The difficulties involved in obtaining enough storage at the well site for the large volumes of water commonly used have been reduced considerably by the use of two recently-introduced storage methods. In one case, special collapsible, rubberized fabric tanks, that can be rolled up to facilitate transportation, are spread out on the ground and filled with water from transport trucks. These tanks have internal supports that prevent them from buckling or rolling. Upon completion of the treatment, the tanks are simply rolled up again and hauled away from the well site. Each of these "whales," as they are called, is capable of containing 400 bbl of water.

A more recent development, still in the experimental stage, consists of a pit lined with polyethylene film. The pit, dredged by a bulldozer, is lined with a single broad sheet of polyethylene plastic film. This, in effect, produces a large pond with a waterproof lining. It will hold water satisfactorily for the treatment without loss by seepage. Cost of excavating such a pit and lining it with the plastic film is much less than that of transporting rigid steel storage tanks.

Size of Treatments

Lower costs of fresh water fracturing jobs enable the operator to give his well a larger treatment. It is an accepted fact that the greater the quantity of fracturing materials injected into the well, the greater the resultant benefit, insofar as increased production and prolonged declines are concerned. Determining the size of fracturing treatment that will be applied then becomes a matter of deciding how much to invest in the well. Naturally, if a larger treatment can be provided for the same cost by the use of fresh water as a fracturing fluid, improved returns can be expected because of the increased stimulation that should result from the larger-volume treatment.

As an example of the large-volume treatments made possible by using a fresh water fracturing fluid, a record-breaking job was performed on July 24, 1956, on a well in the Spraberry area.[2] In this treatment, 200,000 lb of sand, suspended in 250,000 gal of water, were injected into the producing formation at an average rate of 52 bbl per min, under a surface working pressure of 3400 psi (Fig. 1). This well, the Hanley Company Driver No. A-2, was pumping 17 BOPD and 3 BWPD prior to the treatment. A wellhead leak during the treatment caused a brief shutdown, and as a result some sand was found in the casing.

After the well was placed on production, a workover was necessary to remove sand and prevent pump damage. After clean-out was completed, the pump was placed at 6400 ft (approximately 1350 ft above total depth) until such time as production indicated no further sand trouble. Before clean-out, the well produced a total of 249 bbl of oil, 585 bbl of water. After the clean-out, the well was placed on pump and, over a five-week period, produced an additional 1362 bbl of oil and 485 bbl of water, for a daily average of 36.8 bbl of oil and 13.1 bbl of water. This period included one day off for pump parting, two days of engine trouble, and one day to run tubing to 6800 ft. Since the tubing was run, this well has had a daily average production of 69.1 bbl of oil and 23.2 bbl of water.

An interesting feature of this treatment was that an offset well, ½ mile south of the treated well, has reported a change in production. Before the treatment, the offset well was averaging 40 BOPD; following the treatment, it has been averaging 60 BOPD. This would seem to indicate that some communication was obtained with the offset well as a result of this record-size treatment.

May influence spacing. While it is still too early to draw any definite conclusions from the results of one treatment, it would appear highly probable that if the effective drainage area of a well can be extended considerably by the use of large volume fracturing treatments, it might be possible to ex-

ploit an oil pool more economically by drilling wells on a wider spacing. Effective drainage of the reservoir could then be accomplished by the overlapping communication between offset wells resulting from such huge fracturing treatments. If this job proves successful, such large scale fracturing treatments might well influence future drilling practices in the Permian Basin.

Effect of High Injection Rates

The improved results obtained from fresh water stimulation treatments may be largely attributable to the high injection rates employed in forcing sand and water into the formation. Many engineers believe that such rapid injection rates extend fracture patterns to a greater radial distance from the well bore. This extension may result in fewer fractures being induced over the producing interval. However, the greater length of the fractures increases the drainage pattern of the well.

Less hp required. When using fresh water as a fracturing fluid, higher injection rates can be obtained with less horsepower at the surface. When fracturing with oils or other viscous fluids, considerable power is lost in overcoming the friction between the highly viscous fluid and the tubing or casing. When pumping fresh water, which has a higher density and lower viscosity than oil, such friction losses are minimized, with the result that a greater percentage of the horsepower expended at the surface is utilized at the face of the producing formation. Thus, higher injection rates can be obtained at a given pump-engine horsepower when using unthickened fresh water.

Effect on Formation

When fracturing with unthickened water was first introduced, many operators were reluctant to try it on their wells for fear that the large volumes of fresh water injected into the formation would result in water blocks or emulsions that might interfere with the production of oil and thus reduce their ultimate recovery. Such fears have, however, proven groundless. In fact, comparison of fracturing results has shown that, in most cases, fresh water frac treatments resulted in greater production increases than did those in which similar volumes of refined oil were used as a fracturing fluid. Why this should be is hard to explain. It seems evident that fears of damaging the producing formation by the injection of fresh water have been unjustified. The fact that in no case has such a frac treatment reduced production of a well would indicate that no appreciable harm has resulted from exposure of the formations to fresh water.

Preliminary tests. Tests have been run, prior to fresh water fracturing jobs, in an attempt to anticipate any possible factors that might result in a water block being set up in the formation. Emulsion tests have been made on samples of the formation rock, the natural crude, the formation brine, and the fresh water to be injected. In cases where there is a possibility of emulsions being formed, a small quantity of demulsifying agent is incorporated in the fresh water fracturing fluid before it is injected into the formation. Similarly, if there is any indication of possible swelling of clay or silicate particles in the formation, a silicate-control additive is incorporated in the fracturing water.

FIG. 2. **Salt crystals in suspension** in crude oil from the Upper Clearfork formation are shown in this photomicrograph (X200).

A good example of this is the Farmer San Andres formation, which in the laboratory exhibits silicate swelling tendencies. Fresh water fracturing treatments, however, have been successfully made in this formation, resulting in excellent production increases, with no evidence of blocking when a silicate control additive was used. Cost of these additives is negligible, amounting to 1 to 2 cents per gal of fracturing fluid. Apparently, the only conclusion to be drawn is that the possibility of forming water blocks in the formation is remote, or that such blocks can be prevented by the use of proper additives in the fresh water fracturing fluid.

Salt Removal

The overall, improved stimulation resulting from the use of fresh water as a frac fluid would indicate that some additional factor, other than fracturing, is contributing to the increased production of these wells. Because many of the formations in the Permian Basin contain considerable amounts of salt, either imbedded in the matrix or deposited along the flow channels, it has been suggested that perhaps the increased stimulation is due to the removal of such salt by the fresh water fracturing fluid.[4] Analyses of returned water, following many fracturing treatments, have shown that it contains large quantities of dissolved salt. For example, a well completed in the Yates sand was fractured, using 28,500 gal of fresh water and 20,000 lb of sand. This well made little water before the treatment, and returned an estimated 21,000 gal of saturated salt water before continuing water-free production. It was calculated that this represented 54,000 lb of salt.

Removal of this much salt would provide considerable enlargement of formation flow channels, in addition to the expected fractures. It might be expected that such enlarged channels would facilitate the drainage of oil from the matrix into the fractures when production was resumed. By comparison, in an acidizing job, 36,000 gal of 15 per cent hydrochloric acid would be required to remove 68,000 lb of calcium carbonate in order to provide an equivalent increase in porosity in a limestone formation.

Formations classified. Studies are currently under way to classify the different formations in the Permian Basin area on the basis of their salt content, in order to predict more accurately the wells in which additional benefit may be expected through salt removal. Such predictions are being based on three factors: First, salt content of the oil; second, salt content of the natural formation brine; and third, salt content of cores from the producing formation. (See Table 2.)

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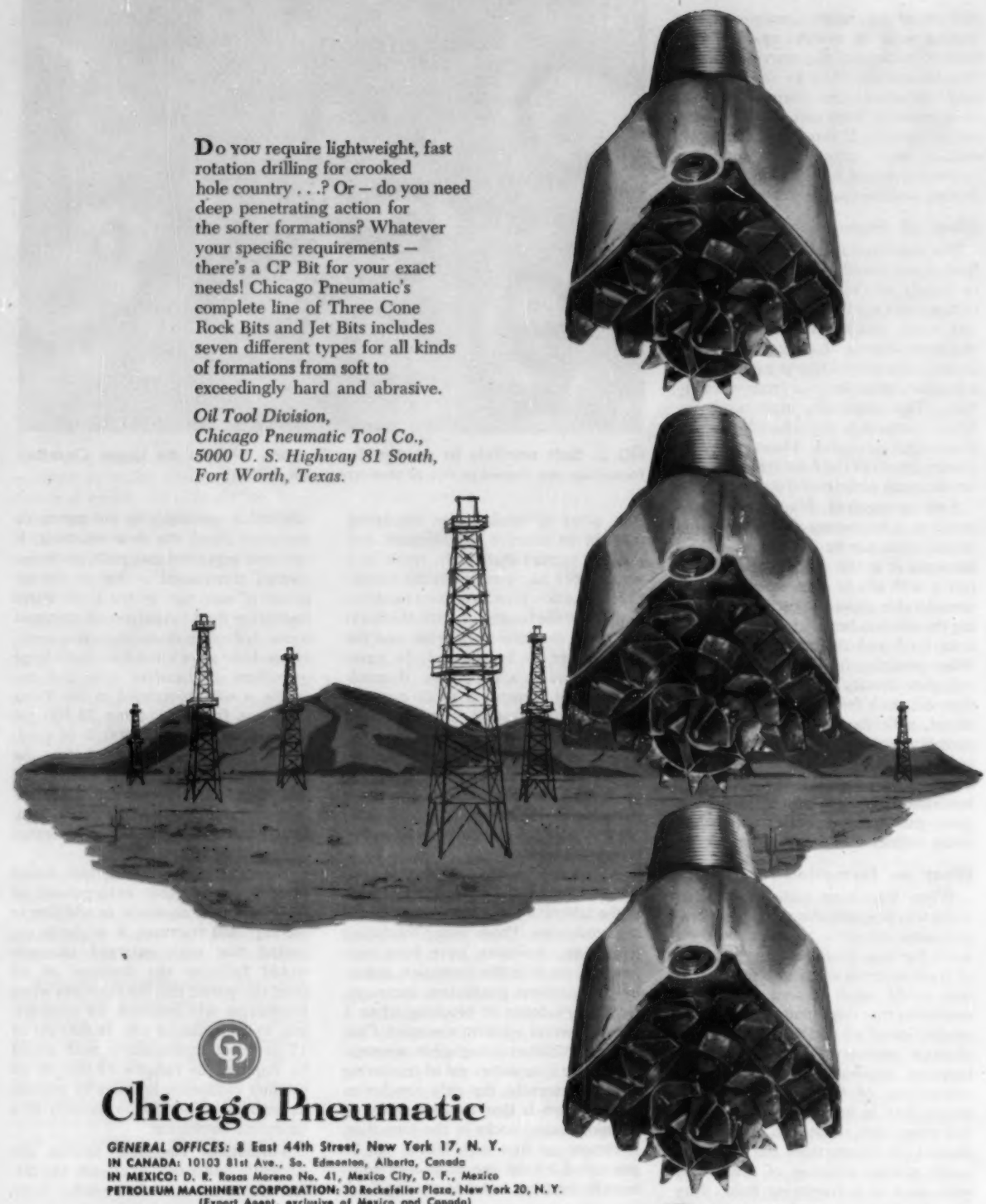

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When running casing, too, timing is vital. It must not be run faster than the mud column can be displaced, (because of destructive hydraulic pressure surges), yet if it is run too slow, valuable rig time is wasted. Stopping casing movement can cause gelled mud, drill cuttings and sloughings to pack off against the pipe and stick it. To avoid these dangers, casing must be run in one smooth operation.

After scratcher and centralizer-equipped casing is run, it must be reciprocated long enough to remove all excess hole growth, and until gelled mud and cuttings are circulated out. In certain wells this can take up to several hours. Here again timing is vital.

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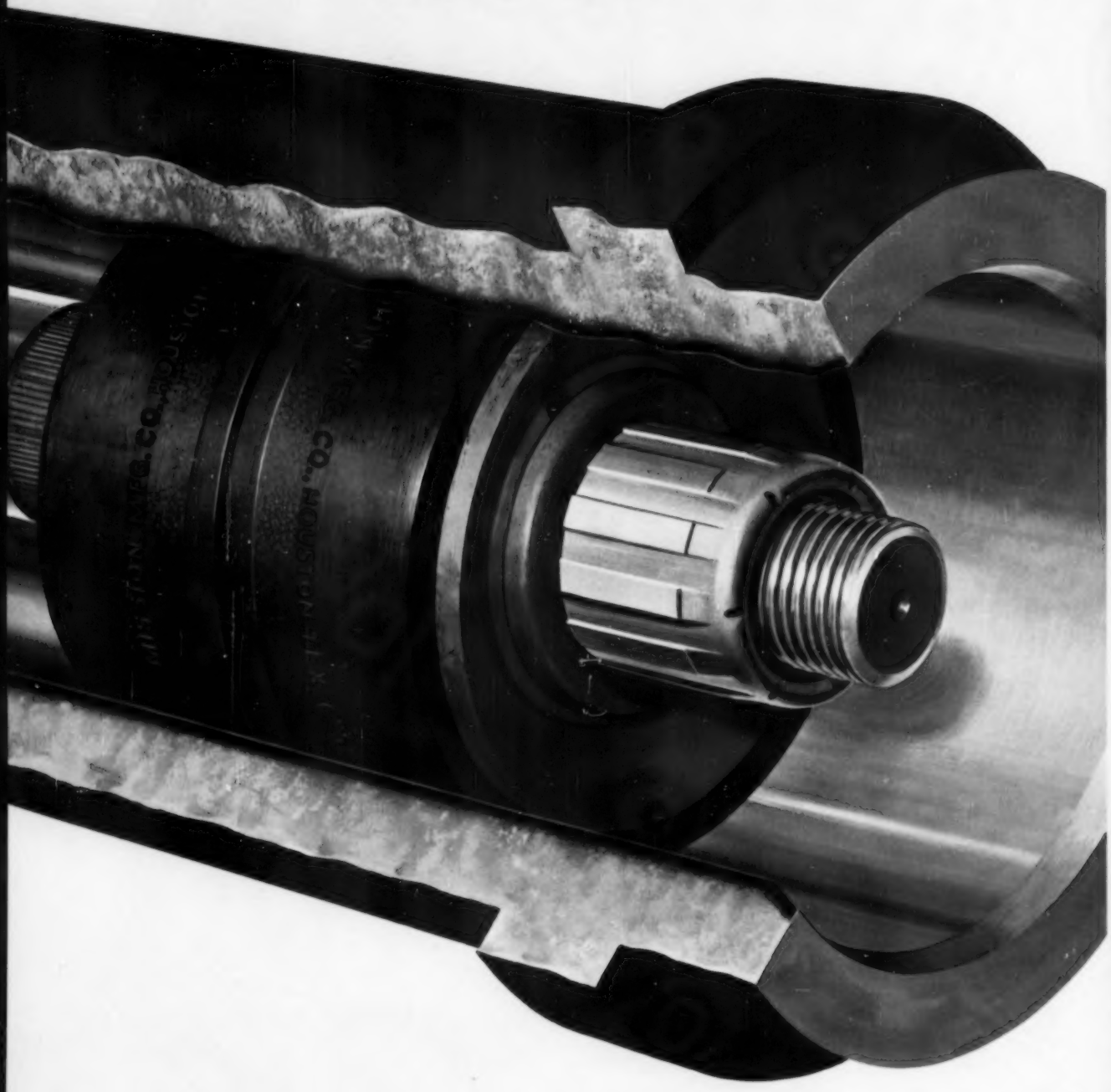
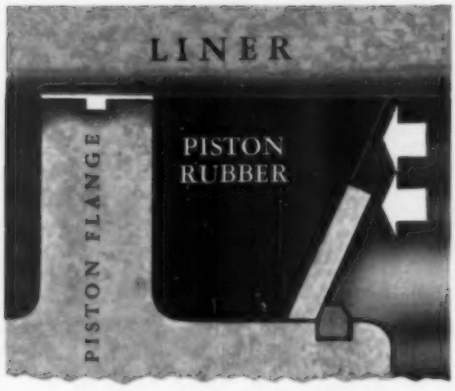
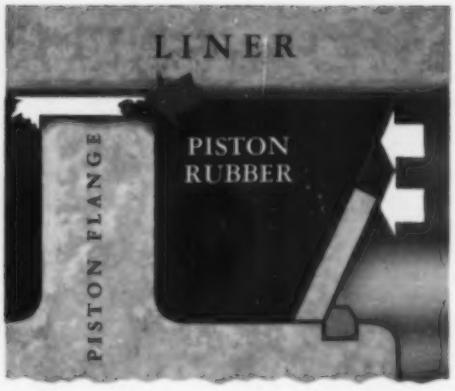




When liner and piston flange fit closely, pressure can not extrude rubber into the clearance to be pinched off. A close fit between piston and liner eliminates the main cause of piston failure and greatly extends piston life.



An important cause of piston failure is excessive clearance between the piston flange and liner. When pump is operating, pressure forces a part of the piston rubber between the space where it is pinched off. This action seriously shortens piston rubber life.

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Crude analysis. Analyses of crude oils from Permian Basin formations have shown that many of them contain as much as 1700 lb of salt per 1000 bbl of oil. Quantities over 100 lb per bbl are considered as high. The salt content of such oil samples has been determined by extraction and electrometric titration in the laboratory. It has also been detected microscopically, in the form of small crystals suspended in the oil, as shown in Fig. 2.

Formation water. Analysis of formation brines is considered a good indication of the salt content of the formation from which the brine was produced. Logically, a brine that is saturated with salt might be expected from

TABLE 2. Salt Occurrence in Permian Basin Reservoirs.

Formation	Pool	Crude oil (lb/1000 bbl)	Produced brine (%)	Formation (lb/cu ft)	Recommended additive
Queen	Eumont	690.0	—	—	Silicate Control
	E. K. Queen	40.0	—	1.44	Demulsifier
	E. McFarland	800.0	—	1.55	Demulsifier
	N. Means	78.0	21.5	1.66	Demulsifier
Bowers	Hobbs	13.3	14.0	—	Demulsifier
Hermosa Lime	Four Corners	17.0	—	—	None
Gallup	Bisti	17.0	—	—	Demulsifier
Yates	Spencer	410.0	7.1	—	Silicate Control
	Holley	65.6	17.9	—	None
	Kermit	160.0	12.2	—	Silicate Control
	Emperor	790.0	18.4	—	None
	Hendricks	665.0	1.7	—	None
	N. Ward Estes	454.0	11.5	—	None
	S. Ward	473.0	13.1	—	None
	Ft. Stockton	226.0	7.0	—	Demulsifier
	Eumont	650.0	—	—	Silicate Control
	Shafter Lake	468.0	—	29.00	None
Delaware	Mason	9.8	16.0	—	None
	N. Mason	18.1	16.3	—	None
	Tunstill	7.2	11.0	—	Demulsifier
	Wheat	4.2	17.6	1.30	Silicate Control
	S. Orla	20.0	9.3	—	None
Grayburg	Dunes	540.0	0.7	—	Demulsifier
	McCamey	52.0	2.6	—	Demulsifier
	Furhman-Mascho	137.0	7.9	—	Demulsifier
	McElroy	616.0	3.0	—	None
	Vem	420.0	9.6	—	Silicate Control
	S. Cowden	1230.0	5.6	—	Silicate Control
	Eumont	637.0	5.4	—	None
San Andres	S. Cowden	785.0	7.1	—	Silicate Control
	Welch	866.0	5.7	—	Demulsifier
	Adair	10.0	13.0	—	Demulsifier
	Cedar Lake	1007.0	5.4	—	Demulsifier
	Furhman-Mascho	177.0	5.5	—	Demulsifier
	Martin	452.0	6.7	—	Demulsifier
	Slaughter	403.0	24.0	—	Demulsifier
	Littlefield	123.0	24.9	—	Demulsifier
	Andector	164.0	7.0	—	Demulsifier
	Donnelly	514.0	8.2	—	Demulsifier
	Foster	781.0	7.0	—	Demulsifier
	Johnson	790.0	7.7	—	Demulsifier
	Harper	629.0	7.0	0.36	Demulsifier
	Brahaney	432.0	16.0	—	None
	N. Cowden	514.0	3.6	—	Demulsifier
	Goldsmith	30.0	8.8	—	Demulsifier
	Wasson	493.0	15.2	—	None
	Farmer	1233.0	17.6	0.24	Silicate Control
	Sharon Ridge	90.0	11.8	—	None
	Levelland	270.0	19.8	—	Demulsifier
	Corossos	100.0	—	—	Silicate Control Demulsifier
	Olson	80.0	—	—	Demulsifier
	Vacuum	180.0	16.2	—	Demulsifier
	Vaughn	411.0	5.6	—	None
Glorieta	Prentice	197.0	15.2	—	Demulsifier
	E. Goldsmith	160.0	10.6	—	None
Clearfork	Spraberry	79.8	—	—	—
	Dollarhide	894.0	16.6	—	Demulsifier
	Sealy Smith	637.0	12.0	—	Silicate Control
	Martin	61.8	16.2	—	Demulsifier
	Anton-Irish	255.0	6.7	—	Demulsifier
	Andector	135.0	18.0	—	Demulsifier
	Donnelly	452.0	6.0	—	Demulsifier
	TXL	132.0	16.8	—	—
L. Clearfork	Goldsmith	185.0	9.9	—	—
U. Clearfork	Goldsmith	267.0	12.6	—	Silicate Control
	Lee Harrison	155.0	20.0	—	None
	Smyer	164.0	21.4	—	Demulsifier
	Prentice	197.0	15.8	—	Demulsifier
Tubbs #3	Sealy-Smith	123.0	12.4	—	Demulsifier
Tubbs #1	Sealy-Smith	67.5	13.4	—	Demulsifier
Holt	Keystone	316.0	12.4	—	None
	Goldsmith	505.0	9.0	—	Silicate Control
McKee	Keystone	16.5	—	—	None
	Goldsmith	62.0	9.1	—	—
Spraberry	Cope	40.0	12.3	—	Demulsifier
	Spraberry	312.0	12.5	—	Demulsifier
Wolfcamp	Blk 9	12.9	15.2	—	None
Devonian	McElroy	39.0	0.6	—	Demulsifier
	Headlee	—	14.0	—	None
	Russell	360.0	—	—	Silicate Control
	Wheeler	78.3	20.4	—	None
	Blk 9	246.0	3.0	—	—
	Yarbrough-Allen	82.0	—	—	—
	TXL	56.0	14.4	—	Demulsifier
	N. Goldsmith	3.7	—	—	Demulsifier
Fusselman	Sealy-Smith	36.0	14.1	—	Silicate Control
	Goldsmith	26.0	13.8	—	None
Penn.	Blk 9	4.5	13.2	—	—
	Dora Roberts	5.7	12.0	—	Demulsifier
Silurian	Dollarhide	313.0	4.6	—	Silicate Control
	Wheeler	10.2	11.1	—	None
	Keystone	136.0	17.2	—	—
	Andector	23.0	6.9	—	Demulsifier
Ellenburger	Dora Roberts	14.9	7.0	—	Demulsifier
	Wheeler	222.0	3.8	—	Demulsifier
	Keystone	189.0	5.9	—	Demulsifier
	Martin	452.0	2.9	—	Silicate Control
	Sealy-Smith	299.0	8.2	—	Silicate Control
	Dollarhide	337.0	4.9	—	None
	Yarbrough-Allen	25.0	6.9	—	Demulsifier
	Goldsmith	399.0	6.5	—	Silicate Control
	Adair	16.0	20.8	—	Demulsifier

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a formation containing appreciable quantities of salt.

In checking produced water samples, it was found that where small volumes of water are produced, the salt content tends to approach saturation; where large volumes are produced, the salt content is below average. This might indicate that waters with above-average salt content are from within the oil section or flooding waters, while those with below-average salt content are from a zone other than the oil-producing stratum. This theory has further substantiation in the fact that on several wells in which fracture treatments penetrated a water zone, the previously produced brine, although presumably from the oil-producing zone, had below average salt content.

Presence of halite. The third factor, study of the occurrence of halite (sodium chloride crystals) in cores, has been limited due to the unavailability of suitable cores. A research project is in progress to obtain and classify cores from all the major producing formations in the Permian Basin area. Results of this study should be available in the near future. Rock samples (taken from the center of the core, where they will be unaffected by the washing-out action of drilling fluids) are being analyzed for salt content.

Petrographic studies. In addition, petrographic studies of thin sections from these cores have done much to reveal how salt is incorporated into the structure of the rock. In many cases, it exists as crystals individually imbedded in the matrix of the rock. In other formations, it occurs as layers or streaks running through the rock. Such occurrence would tend to cause planes of weakness that might be expected to open up during a hydraulic fracturing treatment.

In some sandstones, the salt has been observed as being the cementing material holding the individual quartz grains together. It might be expected that loose sand would be released along the fracture faces in such formations, following a fresh water treatment. This should not, however, result in excessive sand production, because the propping sand retained in the fractures should hold back any unconsolidated formation sand.

A typical example of this may be seen in Fig. 3, which is a photomicrograph (X300) of a sandstone core taken at a depth of 4430 ft, a short distance above the Queens formation, from a well in Ector County, Texas. In this photo may be seen the individual mineral grains. The grain lettered O is orthoclase; the one lettered M is microcline; the remainder are quartz. The cementing material between these grains is halite, or salt. This is readily identified by the abundant small cubical or rectangular voids. All of these voids probably contain water, as evidenced by moving gas bubbles in some of them (indicated by arrows). Single crystallographic orientation of the halite over appreciably large areas is shown by the parallel arrangement of the sides of the scattered voids.

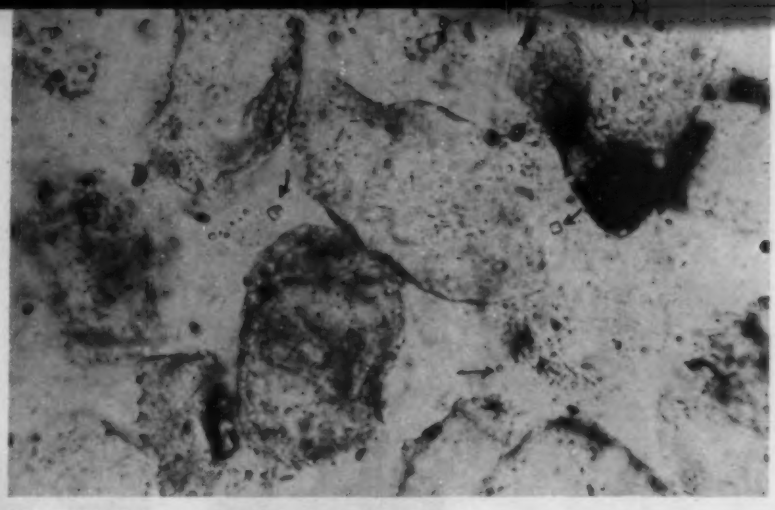


FIG. 3. **Halite is cementing material** between sand grains in this Permian sandstone core (above Queens formation) from a well in Ector County, Texas, as shown by this photomicrograph (X300).

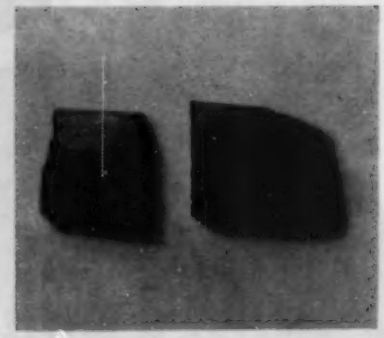
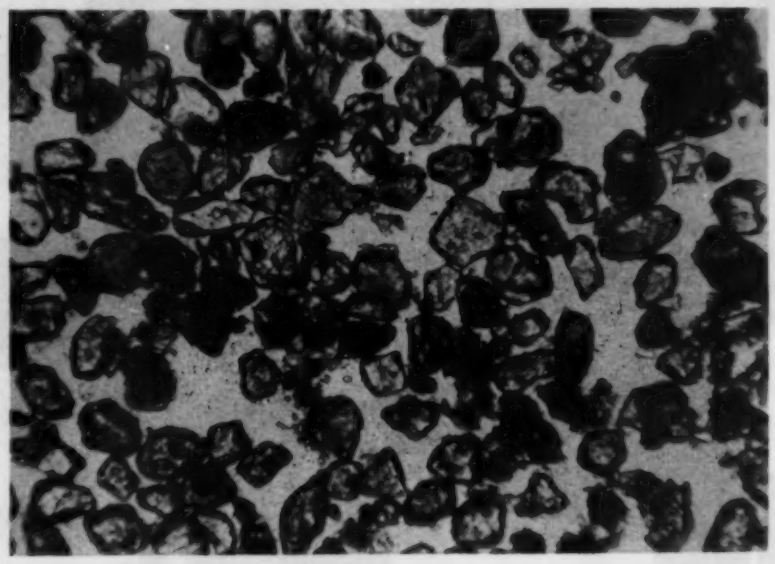


FIG. 4. **Halitic sand core** showing orientation of fractures along crystal faces of the halite cementing material.

FIG. 5. **Loose quartz sand grains** remaining after washing out the halite "cement" with fresh water is shown in this photomicrograph (X69).



This orientation of the salt crystals results in a tendency for the rock to split along definite cleavage planes, as shown in Fig. 4. Surface areas of "breaks" exhibit a distinct sheen when they are turned to reflect light. Such orientation can also be observed under a binocular microscope. Fig. 5 is a photomicrograph (X69) showing the loose quartz sand grains left after wash-

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ing the halite cementing material out of the core with fresh water.

Adding acid. In some wells, where the salt has been shown to be intermixed with lime deposits in the rock, use of low concentrations of hydrochloric acid in fracturing water has been recommended. Such acid would be valuable in breaking down calcareous barriers and exposing the salt to the water treatment. High concentrations of acid are undesirable because they would reduce the salt-dissolving capacity of the water.

There is also the possibility that various salts, other than sodium chloride, may be removed by fresh water. Such salts often occur as secondary deposition in the formation flow channels. When a reservoir is tapped by a well, the fluid equilibrium changes. It is possible that, as a result of these changes, various dissolved minerals, at saturation in the formation brine under static conditions, may precipitate out in the vicinity of the well bore. Contact of reservoir fluids with encroaching brines may also cause salt to precipitate, resulting in partial blocking of the flow channels. Removal of these deposits can certainly increase the well's production.

Predicting results. Table 3 shows an unproven chart of well predictions. It is believed that this table, based on the salt content of the oil, brine, and rock, should indicate results obtainable when properly treated water is used, and when the fracture treatment is mechanically successful. This chart is based on incomplete laboratory data, and may be subject to revision when the current core study program has been completed. In any event, these predictions are based on the premise that **better** results should be obtained by the use of a fresh water fracturing fluid than by using an oil base fracturing fluid. It should be kept in mind that even in cases where salt removal is not an appreciable factor, other advantages accruing from the use of fresh water (economy, safety, ease of application, etc.) may make it preferable to other types of fracturing fluids.

TABLE 3. Predicted Results of Fresh Water Fracture Treatments Based on Salt Content.

Salt in crude	Salt in brine	Salt in rock	Prediction
High	High	High	Excellent
High	Low	High	Good
High	Low	Low	Good
High	High	Low	Good
Low	High	High	Good
Low	Low	High	Good
Low	High	Low	Fair
Low	Low	Low	Fair

NOTE: *High* for *crude* content refers to those oils containing over 100 lb per 1000 bbl.
High for *brine* content refers to those brines of over 5 per cent.
High for *rock* content refers to those rocks containing over 0.3 lb per cu ft.
The *prediction* is based on better results being obtained than if oil fluids are used.

Results of Fresh Water Treatments

Although the application of fresh water fracturing fluids to the treatment of oil wells in the Permian Basin is a relatively recent development (within the past year), its use is spreading rapidly. More than a hundred fresh water fracturing treatments have been performed in the Permian Basin area. Table 4 is a summary of the wells that have been so treated, upon which production data are available.

Gratifying production increases have been obtained from these fracturing treatments. It is estimated that, of the first one hundred treatments, approximately 80 per cent will pay out and show a substantial profit; that is, additional production derived from the treatment will more than offset cost of the fracturing treatment.

On the other hand, approximately 10 per cent of the treatments will break even, while another 10 per cent will be failures, that is, they will not harm the production of the well, but they will not appreciably help. Usually, in such cases, the well is already producing the maximum that the reservoir will supply. If the oil is not available in the reservoir in the first place, the fracturing treatment will not put it there.

Concept is new. The whole concept of using fresh water as a fracturing

TABLE 4. Unthickened Fresh Water Fracture Treatments in the Permian Basin.

Formation	Pool	Depth	Completion Date	Initial Pot. (BOPD)	Frac Materials Water (gal)	Frac Materials Sand (lbs)	Pressure psi	Inj. Rate BPM	Production BOPD	Before BWPD	Production BOPD	After BWPD
Grayburg	McCamey	2100	1941	287	112,500	90,000	2000	41.7	1	½	5	14
San Andres	S. Cowden	4000	1955	118	55,000	40,000	900	46.0	0	6	15	125
Yates	Shafter Lake	3000	1953	226	34,000	20,000	1800	29.7	7	0	28	1
San Andres	Johnson	4100	1941	441	40,000	20,000	1200	32.0	3	1	24	24
Grayburg	Vem	4200	1956	New Well	33,000	30,000	800	25.5	0	0	21	90
Yates	Shafter Lake	3000	1953	252	28,000	20,000	1900	21.0	2	0	60	0
Yates	Shafter Lake	3000	1952	1	28,000	20,000	1800	27.0	0	0	92	6
Yates	Shafter Lake	3000	1954	38	56,000	30,000	1800	28.7	2	0	22	0
Yates	Shafter Lake	3000	1953	150	30,000	10,000	1300	24.8	3	0	4	½
Yates	Shafter Lake	3000	1952	150	33,000	21,000	1900	41.7	2	0	8	0
Yates	Shafter Lake	3000	1952	158	39,000	20,000	2000	35.0	1.5	0	19	24
Yates	Shafter Lake	3000	1951	240	35,000	20,000	2000	34.2	½	0	0	5
Yates	Shafter Lake	3000	1953	135	33,000	20,000	1900	32.2	½	0	20	7
Grayburg	Dunes	3600	1956	New Well	34,192	10,000	1400	36.	New Well	—	108	4
San Andres	Sharon Ridge	1800	—	10	20,000	20,000	1100	16.5	0	1	14	1
San Andres	Sharon Ridge	1800	1956	New Zone	20,000	20,000	900	19.5	½	½	27	2
Glorieta	Diamond M	2400	1953	New Zone	20,000	20,000	1000	18.5	0	0	21	7
Grayburg	Paul Moss	4000	1956	New Well	30,000	30,000	2400	40.0	0	0	28	5
Red Sand	Corbin	4200	1955	36	9,000	3,000	2400	5.0 (thg)	0	0	24	5
Spraberry	Spraberry	5000	1956	New Well	71,400	50,000	2600	35.5	Swabbed Dry		40	25
San Andres	Post	2800	1950	110	30,000	20,000	400	22.0	7	50	50	50
Grayburg	S. Cowden	4500	1955	100	63,000	75,000	200	70.0	7	7	38	100
Queens	Caprock	3000	1954	20	58,800	50,000	1700	30.0	9	1	27	2
San Andres	Vaughn	1450	—	145	20,454	10,000	800	40.5	6	0	86	10
Yates	Kermit	2800	1955	25	20,000	10,000	800	31.8	1	—	40	6
Queens	E. E. Queens	4400	1955	81	50,000	30,000	2500	30.0	10	10	50	10
Spraberry	Spraberry	7700	1953	—	250,000	200,000	3400	52.7	17	3	75	20
Grayburg	N. Donnelly	41	1956	—	123,900	100,000	1600	50.5	10	—	36	168
Queens	Drickey Queens	3100	1955	140	30,750	30,000	1800	19.2	16.5	0	36	4
Yates	South Ward	2200	1956	New Well	21,500	10,000	1000	28.4	New Well	—	18	1
San Andres	Vaughn	1450	1950	—	21,500	10,000	1000	34.2	5	—	60	15
San Andres	Vaughn	1450	1950	—	22,000	10,000	1300	34.	1	0	27	25
San Andres	Vaughn	1400	1949	—	16,100	10,000	2800	22.	4	0	30	2
Yates	Kermit	3000	1955	—	22,000	10,000	1000	34	1	—	144	52
Queens	Emperor	3000	—	—	58,800	42,000	1500	41	20	0	25	35
San Andres	Welch	5000	—	—	29,000	10,000	1200	20	1	1	11	81
San Andres	Fuhrman-Mascho	4600	1634	—	42,000	30,000	3100	24 (3 thg)	5	2	40	5
San Andres	Vaughn	1450	1950	—	17,000	10,000	800	25	5	1	40	9
San Andres	Vaughn	1450	—	—	19,200	10,000	1000	32.5	8	3	98	21
San Andres	Vaughn	1410	—	—	33,000	20,000	1050	42.4	5	0	85	25
San Andres	Vaughn	1400	—	—	21,000	10,000	1500	32	3	—	4	—
Delaware	S. Orla	3400	—	—	42,000	30,000	1850	30	½	80	15	150
Yates	Shafter Lake	3000	1953	—	31,504	30,000	1900	25.0	0	0	25	28
Yates	Shafter Lake	3000	1953	5	29,000	20,000	2100	25.8	0	0	74	16
San Andres	Maljamar	3500	1943	22	36,900	30,000	3000	21.9	2	0	20	8

fluid is so new that operators are naturally curious, not only about results that are being obtained from such treatments, but also as to the exact mechanisms that are responsible for such results. Many operators who have in the past carefully drilled into producing horizons with oil-base fluids in order to avoid any possible water infiltration, now are called upon to inject huge quantities of fresh water into these same producing horizons.

There seems to be no question but that greater stimulation increases are being obtained with fresh water than with oil-base fracturing fluids. An oil fracturing treatment provides no means of increasing the permeability of the matrix, and therefore cannot be classed as a highly efficient treatment. By contrast, these fresh water treatments, in addition to creating a fracture pattern and cleaning the fractured surfaces, increases the effective permeability of the rock itself by dissolving salt and thus enlarging the individual flow channels.

Summary of Fresh Water Frac Treatments in the Permian Basin Area.

Number of jobs (as of 10/1/56)*	69
Number of formations treated	9
Most treated formation	San Andres
Average depth	2,982
Total gallons of water injected	2,734,800
Total pounds of sand injected	1,939,200
Average gallons water per job	41,437
Average pounds sand per job	28,943
Average injection rate	34.2 bpm
Average injection pressure	1,673 psi

*Does not include fresh water fracturing treatments on gas wells in the San Juan Basin gas field.

The whole question of salt removal is highly controversial. Some believe that large amounts of salt are being dissolved from the formation rock. Others believe that it is merely a case of dilution and removal of connate water from the formation. Whatever the cause, there can be no question that spectacular production increases are being obtained, and it seems certain that the use of fresh water as a fracturing medium may soon revolutionize fracturing practices in the Permian Basin.

Acknowledgment

Petrographic photomicrographs and data in this article were supplied by W. A. Waldschmidt, consulting geologist, Midland, Texas.

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New Storage Ideas Cut...

Fresh Water Fracturing Costs

Service costs in using unthickened water for fracturing purposes have been reduced considerably by the introduction of new methods for storing the necessary fresh water at the well location. Idea behind these two storage techniques developed by Dowell Incorporated is to substantially reduce the trucking and rental costs for the required number of large steel tanks normally used. If the cost can be cut on the simple requirement of adequate storage for the larger volume fresh water fracture jobs, the overall cost will be reduced accordingly, and thereby lend encouragement to the larger and more productive fracture treatments.

Rubberized canvas tanks. Introduced a few months back was a large rubberized canvas tank popularly termed "whale." They are oblong in shape and have a capacity of 400 bbl of water. When collapsed, each canvas "whale" could be rolled up on a corrugated metal reel and several such units carried on a single truck. Each "whale" was equipped with the necessary connections to allow it to be filled and pumped out. They can be set up quickly and rolled up and moved in much less time than is required to load a single steel tank of similar capacity.

Latest innovation. The most recent idea in cutting storage costs of large volumes of fresh water at the well site consists simply of a pit lined with expendable polyethylene film. These pits are easily constructed. It is excavated by a bulldozer, with the bottom sloping toward one end. A sump is dug at the point where the pump truck intake lines enter the pit in order that nearly all the water can be pumped out. A large sheet of this plastic material, measuring 0.003 in. thick, and available pieces up to 80 ft by 400 ft in size, is placed inside the excavated earthern pit.

In a recent frac treatment near Hominy, Oklahoma, a pit 55 by 75 ft and about 8 ft deep was lined with the polyethylene film is about 45 min. It held 2200 bbl of fresh water for the frac treatment. Cost of the 8000 sq ft of film was $400, plus $130 to cover cost of digging and refilling the pit, making a total of $530. This is about the rental cost for 1000 bbl of steel tank storage.

The polyethylene film is flexible over a wide range of temperature and is resistant to mechanical damage, weathering and deterioration.

Rubberized canvas "whales" (left) on location and filled with 440 bbl fresh water for use in frac job. When collapsed, canvas tanks are rolled up on reels in foreground. **Thin tough plastic film** (right) of polyethylene lines earthen pit to hold necessary quantities of fresh water for frac job. Storage costs are drastically cut, and these open pits can be constructed quickly. Plastic film is expendable.

CASING AND TUBING Enough For Tomorrow's Drilling?

Supply of oil country tubular goods has lagged behind demand for 10 years. Operators will be able to get *most* of the material required for stepped up drilling through 1960

H. W. Ladd
Stanolind Oil and Gas Company, Tulsa, Oklahoma.
Chairman, API Central Committee on Standardization of Oil-Field Equipment

DURING most of the time since 1946, oil and gas development and production operations have been handicapped and curtailed in various degrees by inability to obtain required quantities of such tubular materials from normal sources of supply. These are the steel-pipe mills of domestic manufacturing concerns, whose mills are specifically designed and equipped to produce these highly specialized oil-country tubular goods as their principal product, although line pipe and other pipe is also made by most of these same mills.

To understand present conditions and provide a basis for forecasting the future, it is necessary to review and analyze the many factors that have caused this decade of short supply. Fundamentally, the condition has been the result of a dynamic and unprecedented expansion of our national economy that has created, in nearly every market, a demand greater than supply. Contained therein is the cause of the oil industry's troubles — lack of steel and of adequate oil-country tubular-goods production to meet the rapidly increasing requirements of the petroleum industry.

Peak Production in 1966-75

Economists, analysts, and other competent authorities are constantly studying the ever-increasing growth of petroleum demand and supply in order to develop criteria upon which trends may be based in order that rational projections may be made of the future, for the guidance of businesses interested in or connected with the petroleum industry. Without exception, the later forecasts predict increases over earlier estimates of future demand and supply, for at least the next decade; and forecast a peak of domestic production in the decade 1966-75.

One such report shows that for the past 23 years, domestic consumption of oil has approximated a 5.8 per cent annual growth, compounded. Even though this trend was temporarily interrupted by economic disturbances (recessions, depressions, and wars), the growth was resumed at the same rate thereafter. It is now predicted that this trend can be reasonably assumed to continue for at least the next 10 years. Tables 1 and 2, illustrating the growth rate of domestic demand and supply, have been selected from available forecast date.

TABLE 1. Domestic Demand Trend.

Year	Petroleum, thousand bbl per day	Gas, billion cu ft per day
1946	4,900	11.0
1950	6,500	17.3
1955	8,400	25.8
1956 (est.)	8,900	27.1
1960 (est.)	10,400	35.3
1965 (est.)	12,500	43.0

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TABLE 2. Domestic Supply Trend.

Year	Petroleum, thousand bbl per day	Gas, billion cu ft per day
1946	5,067	11.0
1950	5,906	17.3
1955	7,532	25.8
1956 (est.)	7,855	27.1
1960 (est.)	9,150	33.7
1965 (est.)	10,200	38.9

Continued increase in demand for petroleum products and natural gas will call for a maximum effort to maintain the high-level relationship between domestic production and reserves that now exists. An ever-increasing number of wells will be necessary to find and produce the required volumes, (Table 3.)

TABLE 3. Total Wells Drilled in the United States*

Year	Number	Average Depth, feet	Footage Drilled, thousands of feet
1946	29,229	3,321	97,070
1950	43,279	3,680	159,267
1955	56,682	3,974	226,270
1956 (est.)	59,100	4,096	242,109
1960 (est.)	69,800	4,546	317,356
1965 (est.)	84,200	5,212	438,850

*Estimates given are based on the rates of annual increases established as the trend since 1945, viz., 4.8 per cent for number of wells and 7.0 per cent for footage drilled.

The increases forecast for the next decade may appear amazing and even incredible, but are no more so than the actual growth during the past decade. It is interesting to note that past forecasts have consistently fallen short of actual accomplishments — and many of those forecasts were considered fantastic.

Oil's 7 Per Cent Share

The steel industry in particular has been subjected to a tremendous impact by the rapidly increasing national demand for all of its products. In this advance of steel production, our position has not been too satisfactory. The tubular-goods mills collectively have not always received the steel needed to maintain the maximum production required to meet petroleum-industry needs.

The oil and gas industry is reported to receive directly from steel mills and mill distributors only about 7 per cent of the total steel produced in this country. This percentage does not include the steel required for the manufacture of machinery, equipment, containers, and other materials used by us. Of this 7 per cent, about 3 per cent is oil-country tubular goods, perhaps a surprisingly low figure to some of you. It may be of interest also to see where oil-country goods stand in the overall pipe and tube manufacturing picture. Here is the 1955 production record:

	Tons	Percentage
1. Line pipe	3,063,736	31
2. Standard pipe	2,968,241	30
3. Oil-Country tubular goods	2,542,109	26
4. Mechanical tubing	965,829	10
5. Pressure tubing	276,068	3
	9,835,983	100

It is estimated that the oil and gas industries together use about two thirds of the total pipe and tube production, even though only a small percentage of the standard pipe, mechanical tubing, and pressure tubing tonnage is used by those industries.

Between 1946 and 1953, the mills did little to increase their production capacity for oil-country goods, but did increase tremendously their capacity for electric-welded line pipe. The unprecedented demand for line pipe, and particularly for large-diameter transmission line pipe, undoubtedly had a considerable adverse effect on oil-country goods production; and was partially responsible for the fact that steel for such production was often not available.

That was a period of complex and rapidly changing conditions. In the early portion of this decade, there was a general shortage of steel available at normal prices, producing a black or gray market situation. A short recession period followed; then came the impact of the Korean situation, climaxed by the complications caused by a general steel strike.

Since 1953, production capacity for oil-country goods has been increased about 58 per cent, and currently approximates 2,900,000 tons annually. This increase has resulted principally from the constuction of two new seamless mills and two new electric-weld mills with a total annual capacity of some 600,000 tons. During this same period, the existing mills did much to revise their production patterns to more closely meet the demand for casing and tubing in grade N-80 and higher, and for a greater proportionate production of oil-well tubing. A large quantity of special manufacturing and heat-treating equipment was required to make these changes.

Each year in the past 10 (except 1949) has seen an increase in oil-country tubular goods production by domestic mills in spite of many difficult conditions and interruptions that often include shortages of steel. The total increase for the period was 60 per cent. Even so, rate of production has generally been inadequate to meet the more rapidly increasing demand for oil-country tubular products.

Alternate Supply Sources

In efforts to offset this shortage from regular mills, some operators have been forced to resort to abnormal sources of supply, paying high premiums in most cases; and sometimes accepting material of undesirable quality. Material purchased from these abnormal sources of supply have included:

(1) Premium-priced raw steel converted into pipe or tubes by oil-country or other pipe and tube mills, and finished by the converting mills or outside source as casing or tubing. (This can be done only when mill space is available as the result of shortage of regular-price steel for normal production, as in 1947-48-49.)

(2) Plain-end pipe or tubes from any available source, domestic or foreign, finished by outside sources as casing or tubing.

(3) Foreign oil-country tubular goods.

(4) Line pipe and standard pipe, for use as casing or tubing when conditions permit.

(5) Used casing, tubing, and drill pipe.

Availability of material from any of these sources varies greatly according to conditions. Only a relatively small amount of conversion casing and tubing has been manufactured during the past few years because of lack of available steel and/or mill space. The purchase of plain-end tubes for finishing continues to be the most important supplemental source for critically short oil-well tubing. The addition of oil-well tubing capacity, recently installed or contemplated by several mills, will reduce the necessity for such purchases accordingly. Expansion of the petroleum industry in foreign-fields has reduced the availability of oil-country goods manufactured abroad for import to the United States of America. It is estimated that about 65,000 tons of foreign casing and tubing will be imported during 1956 for use in the United States. It is improbable that a greater tonnage will be available to us in the future, in spite of the fact that three new foreign mills will soon be completed.

Physical properties of line pipe and standard pipe limit their use as casing or tubing to wells having shallow depths and low pressures. Such pipe also is in short supply.

Used material available for purchase affords is a small but consistent source of supply, because most salvaged pipe is retained for use by the original owner.

Casing and tubing available for domestic use from all these abnormal sources is expected to total about 200,000 tons in 1956. The amount of casing and tubing salvaged by operators for their own use should provide another 200,000 tons. The expected quantity of total mill production, estimated at 125,000 tons, must be deducted. The net tonnage available from sources outside the regular mills will therefore total 275,000 tons, or 11 per cent of the anticipated total yearly re-

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  The fracturing and carrying fluid used in the Sandoil Process is an inexpensive, readily obtainable crude, or refinery cut or blend. Resulting economy makes very large-volume, high-rate ("Big Frac") fracturing, with its vastly improved results, economically feasible.

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  Effective use of these inexpensive fluids to open gigantic pay-zone fracture systems is made possible by Halliburton's unparalleled equipment. Top-volume pumping units that deliver most efficient hydraulic (in-the-formation) horsepower. Exclusive, continuous, high-rate, variable-ratio proportioning units that "spudded in" a new era of formation fracturing.

- **SKILLED MANPOWER**
  Behind the thoroughly trained operators who use the Sandoil Process to create vast "oilsheds" in productive formations... stand seven years of Halliburton Fracturing... thirty-three years of Halliburton research and experience on more than three million well jobs.

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COMPLETE DATA SENT ON REQUEST
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quirements. It does not seem probable that this quantity will increase in the future to any great extent — another 100,000 tons would be the maximum expectancy.

Many different manufacturing arrangements of mill equipment exist among the concerns that produce tubular goods. A particular mill or mills within the same company may produce oil-country goods only or line pipe only. Many make all types of pipe on the same mill or mills.

Steel Distribution

Inside the total mill capacity-production relationship lies the capability and desirability of meeting user demand for the various types of products. It is obvious that the quantity and item distribution should be controlled to best fit the individual manufacturing picture. The tonnage set up for the manufacture of oil-country goods must be further divided to meet the producing conditions. Although the circumstances vary greatly among these manufacturing concerns, the overall distribution pattern for the year (shown following) will give you a close estimate as to how the oil-country business splits up.

	Per cent	
Casing	77.0	(20% in grade N-80 and higher)
Tubing	18.6	(16% in grade N-80 and higher)
Drill pipe	4.4	(76% in grade E and higher)
	100.0	(26% in all high grades)

When demand exceeds supply, the sellers control. This condition has existed for some time with oil-country goods and has resulted in a system of distribution by the mills which has been described as voluntary allocation. Any system of allocation in the face of a shortage contains inequities by its very nature, and this is no exception.

Voluntary Allocations

Here are the usual mechanics of ordering, subject to change in accordance with conditions.

For oil-country tubular goods to be delivered during any given quarter, the mills open their order books for the placement of business during the first part of the preceding quarter. Tubular goods are then allocated on the basis of tonnage and of items that can be ordered to make up that tonnage. Following is an example:

Allocation, tons	Size, inches	
300	5½	Max 50% in 14-lb; max 25% grade N-80
400	7	Max 50% in 20-lb; 20% grade N-80; 10% grade P-110.
300	7⅝ and over	Max 30% grade N-80.
90	2⅜ tubing	Max 20% grade N-80.
110	2⅞ tubing	Max 20% grade N-80.
1,300		
100	4½	Grade E drill pipe.

This item distribution is based on a maximum mill-production pattern, and may not suit the operator's well requirements. Some flexiblity is permitted in ordering, but the orders must still conform to the mill pattern.

These allotments may be made by the mill to the operator, who will then place his orders direct with the mill or through representative supply stores. Separate allotments may go direct to the supply store which will make allocation to and receive orders from the operator, or the supply store may order for delivery into its stock for later sale. This is difficult to follow because of the several different situations. It will perhaps simplify this explanation to say that direct mill allocations are usually made to those operators, both majors and independents, who regularly drill many wells per year; whereas the supply-store allotments generally must provide for the needs of operators who drill but few wells. In some cases in which the mill is represented solely by its own supply store, there are no direct mill allocations. One mill has no supply-store representation and therefore handles all orders direct. The point here is that the mill or the supply store presumably to its own best advantage, selects its customers and tells them how much and what they can have.

Few operators have consistently been able to secure allotments from domestic mills for all the oil-country tubular goods they wanted; so the great ma-

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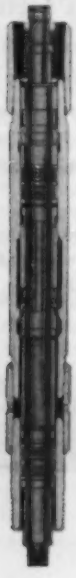

Type S

Otis Side-Door Tools are now available in "S" dimensions... The new, standardized series for Otis "selective" landing nipples.

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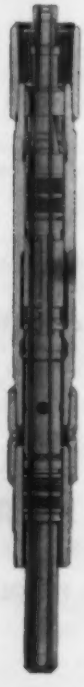

jority of operators, large and small, have not been able to meet all their needs through this source of supply.

Much has been said about excessive inventories being maintained by some operators. I doubt if there are many inventories that comprise an adequate and balanced supply for more than 90 days requirements. Operators with a consistent drilling program have found it desirable (but difficult) to maintain such a quarterly supply as is considered necessary to properly protect their operations. Drilling usually does not start until pipe is actually available. When ordering is done 90 to 180 days in advance of normal delivery, such stocks are not unreasonable and should be maintained when possible.

Oil Producers Recognized

Before proceeding with the investments in equipment which would raise their production to a predetermined proportion of future demands, it seems certain that the steel mills and the pipe mills gave careful consideration to all factors to confirm the existence of a long-range market potential in an increasing volume. It obviously took several years for them to be convinced that the position of the production division of the petroleum industry in this rapidly developing national economy and its relationship to the national defense was basic and sound; and that it would continue to play an important part in its progression, and thereby provide a dependable and ever-increasing demand for oil-country tubular goods for many years.

It is conceivable that a more direct and concerted effort on our part to "sell" our demands for oil-country goods as most desirable business for the steel industry would have developed a higher priority on steel to produce such products and would more quickly have shown the crying need for a higher rate of oil-country tubular goods production in overall mill capacity. We should think about the possibilities of maintaining closer relationships in the future and doing whatever is consistent and necessary to keep our needs high on the desirable list.

The oil-country mills have recently made adjustments and increases that put us in better condition potentially or capacity-wise than we have been in for a long time — one which approximates current demand. It is also apparent that much improvement in mill production patterns has been made, from which more high-strength material such as grades N-80 and P-110 will be available; and the ever-existing and heretofore constantly increasing oil-well tubing shortage may be alleviated or eliminated.

Mill Capacity Increased

The steel companies are committed to a schedule of 15,000,000 tons new capacity in the next 3 years. Therefore, new capacity will increase at the rate of 3,500,000 tons per year until 1965. Further increase in pipe-mill capacity will be made in 1957 and 1958 as one large and complete pipe-mill unit will go into operation, as well as several stretch mills and at least two-electric-weld mills that will produce tubing and small-diameter casing. Existing capacities for oil-country goods also will be expanded further. There are also several large pipe mill units to be added to the picture later if suitable financial arrangements can be made. In the estimate of future capacities (Table 4) it is assumed that these units will be built. Other mills have been contemplated and would be built if assurance of a long term steel supply could be obtained.

As mentioned before, there is no fixed capacity of oil-country goods production by mills, as the schedules are varied to obtain the best possible results in overall production. The maximum production possible, of course, is the total finishing capacities for oil-country items. The mills will not set figures for their oil-country goods capacities and therefore any estimate made

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More than 20 two-zone completion and production operations are possible with Otis Removable Side-Door Chokes, Otis Separation Tools, and related Otis Side-Door Equipment. These Otis sub-surface controls provide a simple and economical method of completing and producing two zones through the same well bore without commingling the fluids. Dual completions allow the economical production of so-called "stray" oil and gas formations which normally would not be feasible nor practicable to produce. If you are about to complete or re-complete a well in a multiple-pay area, talk to your nearest Otis office about installing side-door equipment. They will be glad to give you illustrated literature and complete details without obligation.

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BRANCHES THROUGHOUT THE OIL COUNTRY

OTIS

can only assume the proportion of total capacity that can be reasonably expected, with past experience as the principal supporting factor. Using the meager information available, the estimated mill capacities are shown in Table 4.

TABLE 4. Estimated Mill Capacities Oil Country Tubular Goods

Year	Tons
1956	2,900,000
1957	3,150,000
1958	3,500,000
1959	3,700,000
1960	4,200,000
1965	5,600,000*

*Additional increase in capacity not contemplated at present.

In forecasting casing and tubing demand, 11.4 tons per 1000 ft drilled is used for 1956 through 1959, 11.5 tons for 1960, and 11.6 tons for 1965. This is based on the original rates, established by National Petroleum Council committee reports, projected on the established rate of increase. No sound basis by which it can be increased further is foreseen. It should not be lower than these estimates, in any event.

Table 5 gives the relationship of casing and tubing demand to shipments, and shows the maximum situation to be expected under the conditions anticipated in the steel and petroleum industries. It assumes no interruptions or adverse circumstances beyond the shortage caused by this year's strike, although the full impact of delay in production by the strike has yet to be felt.

TABLE 5. Casing and Tubing, Tons. (maximum)

Year	Possible Demand	Shipments for Domestic Use
1956	2,760,000	2,350,000
1957	2,953,000	2,835,000
1958	3,160,000	3,150,000
1959	3,381,000	3,330,000
1960	3,650,000	3,780,000
1965	5,091,000	5,100,000*

*Depends upon further increase in capacity.

Conclusion

If all the new mills are built and present oil-country goods capacities are expanded according to plans, and if the steel is available as expected, the industry should be able to secure most of the material required to continue under the rate of increase in drilling established by past experience, through the year 1960 at least. After that time a greater increase in mill capacity would be required if the drilling trend continues at the same rate. The steel mills and the pipe mills will continue to control the situation. If demand for oil-country goods is not met and the required number of wells cannot be drilled in this country, the gap between total domestic petroleum production and total domestic demand for petroleum will widen; and the time necessary to reach the peak of domestic petroleum and gas production will be lengthened.

It is probable that shortage conditions will continue to be critical through 1957, as the petroleum industry will be trying to restore the losses in stocks and drilling footage cause by the steel strike of 1956. The prospects of obtaining adequate quantities of oil-country tubular goods for current demand in the next few years, however, are better than they have been for a long time.

Acknowledgment

This paper was presented under the title "Will The Supply of Casing and Tubing Be Adequate for Tomorrow's Drilling" before a group session of the Division of Production during the thirty-sixth annual meeting of the American Petroleum Institute, Chicago, Illinois, November 13, 1956. ★ ★ ★

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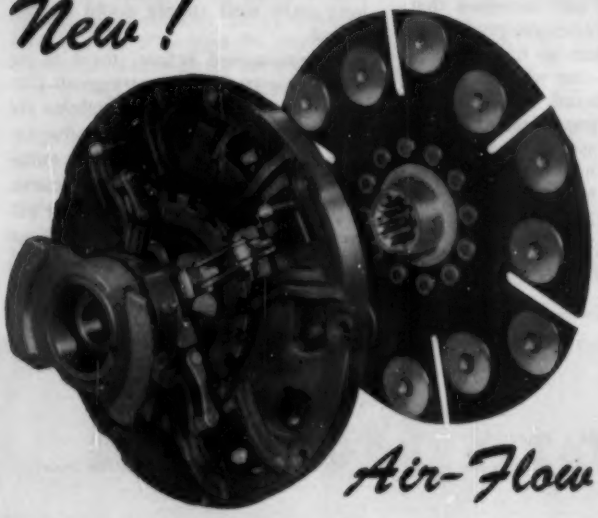

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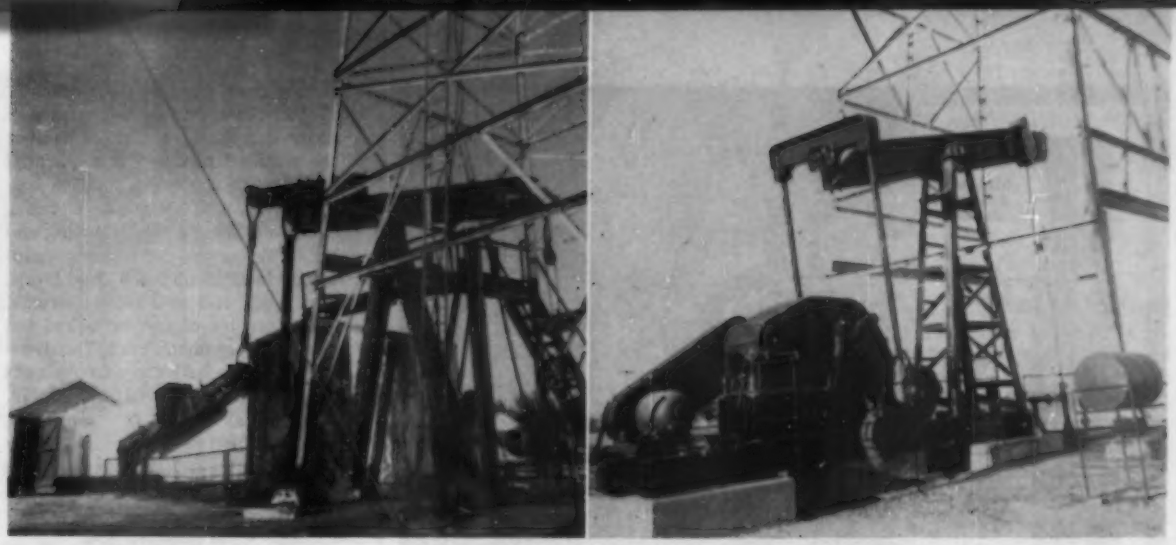

EXCLUSIVE

P 516.921

FIG. 1. **Before and after** planned well studies. Investigations showed installation at left in the Howard-Glasscock field was operating inefficiently. Equipment tailored to well conditions resulted in increased production and higher efficiency in installation at right.

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Peak Pumping Efficiency?

C. J. Merryman
and
Bennie L. Franks
Sun Oil Company, Odessa, Texas

Dwindling production in Odessa, Texas, area halted as dynamometer and other instruments aid planned lease studies to cut lifting costs

SIX West Texas lease studies, using a dynamometer and other testing instruments, have resulted in a total reduction of $7884 in annual operating costs from three of the six leases. Monthly oil production from two leases has been increased 630 bbl. Operating efficiency was increased 40 per cent on the 65 wells tested.

Sun Oil Company field engineers, doubting that production losses were entirely the result of "normal production decline," turned to new equipment in 1954 to conduct individual well and lease studies. Supplemented by complete well histories gathered by the production team — the engineer, foreman and pumper — a testing program was systematically conducted, resulting in improved operating efficiency and increased dollars-and-cents return.

PERSONNEL IN THE PICTURE

Since producing problems originate on the lease, it is through the pumper's oral and written production reports that problems are brought to the attention of supervisory personnel.

As in the past, the foreman or farm boss has the responsibility of supervising lease production operations. He must keep the producing equipment, treating equipment and storage facilities operating to allow the continuous movement of oil from the bottom of the well to the stock tank.

The engineer enters this operating system as a recorder, planner, equipment analyzer, and problem evaluator. Co-ordinated teamwork in study and application by the engineer and foreman, under the direction of the field superintendent, is a primary requisite for improving lifting efficiency.

Readily apparent problems are not the only consideration, for it must be remembered that although a pumping well produces top allowable, trouble free, its operation might still be improved if this same work could be done at a reduced cost.

INSTRUMENTS

Dynamometer

A dynamometer has been in continuous use about two years in Sun Oil Company's Odessa area to help improve the pumping operations in West Texas. The dynamometer is a twin ring type instrument that records the deflection of steel rings which are compressed by the load across their diameters. The ring deflection is directly proportional to the load imposed. This deflection is mechanically magnified by a ratio of approximately 100 to 1 and is recorded by means of a stylus tracing its path on a waxed sheet of paper. The basic principles of the dynamometer were drawn from the proven ring developed by the Bureau of Standards.

The card traced by the stylus of a dynamometer shows a continuous recording of all forces acting on the polished rod at any particular instant during one pumping cycle. This load curve is recorded with respect to the polished rod position and is a composite record from which load analysis can be made in both directions, that is, through the rod string to the pump and through the pumping unit to the prime mover.

The actual load at any point in the pumping cycle is only one of the many

The operating principle of the Type C Otis Gas Lift Valve is so completely different from conventional gas lift equipment that it makes available certain production practices that heretofore have not been possible for wells on gas lift.

Remarkably simple in design and construction, Type C valves can be used for continuous or intermittent flow, they can be used in dual completions, they are adaptable to permanently-completed wells, they can be adapted for casing flow, and certain sizes can be installed without pulling tubing.

A resilient rubber sleeve is the only moving part, and extremely small opening and closing differentials are possible, even with sand-laden fluids. The valve is built *around* a full-opening mandrel (rather than alongside the tubing) which affords greater strength than the tubing itself. The check seals positively and does not require velocity to close. When used in an intermittent operation, a minimum amount of gas is required to lift the load of fluid, regardless of surface choke settings or long flow lines.

The Type C Otis Gas Lift Valve has so many significant advantages that we believe it has advanced gas lift technology by at least ten years. Ask an Otis man why.

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facts obtained from a dynamometer card. The dynamometer can be used to measure the effective counter-balance at the polished rod, which is essential when calculating peak torque or balancing wells from dynamometer cards, and indicates whether the traveling and standing valves are functioning properly. Rod loads, fluid loads, fluid levels, tubing leaks, rod and tubing stretch, and plunger travel can be calculated from the dynamometer card. The dynamometer also records the unusual loads caused by sticking pumps, paraffin, crooked holes, pump-off conditions, gas locks, parted rods, and other sources of pumping inefficiencies. The instrument measures the actual horsepower being transmitted to the sucker rod string at the polished rod.

When data available from dynamometer cards are interpreted correctly, they serve as a reliable guide to more efficient and economical pumping practices. It would be impractical to consider in detail all of these factors each time a well study is made, as each well study could conceivably be extended into a long term project rather than serve the practical requirements of quickly finding the answer to a specific problem. Since mechanical failures are primarily responsible for excessive lifting costs, the above factors should be considered when making changes.

It is important to gather all available data on the well equipment and on the special characteristics of a well prior to dynamometer work, especially as to whether the problem developed suddenly, or whether there had been an extended decline in production. Calculation of pump efficiency utilizing rod stretch, tubing stretch, and over or under travel of the plunger will establish pump capacity versus total fluid produced. A brief talk with the pumper will often reveal the true well problem as he is more familiar with the peculiarities of the well than anyone else. Half the work in solving the well problem is completed when the above data have been obtained.

There are many auxiliary instruments which are of assistance in dynamometer work on electrified leases. Those used in Sun's Odessa area are the watt-hour meter, the recording ammeter, the recording voltmeter and the instantaneous volt-ammeter. A liquid level recorder is an excellent aid in studying pumping well production.

Watt-Hour Meter

The watt-hour meter records the energy required for a single well or a lease over an interval of time. The meter has a thermal demand unit that records the maximum number of kilowatts drawn during any 15-min period

FIG. 2. **Dynamometer installation** on polish rod utilizing hanger assembly. Installation takes only a short time.

plus indicating the instantaneous kw demand. The main purpose of the watt-hour meter is to determine the total energy consumed per well along with its kw demand, which can be converted to actual cost or horsepower used to pump that particular well. From the polished rod horsepower recorded on the dynamometer card and the watt-hour horsepower indicated by the watt-hour meter, all efficiency losses occurring in the electric motor, V-belt drive, and individual pumping unit can be calculated.

Recording Ammeter

The recording ammeter is a permanent magnetic moving coil instrument for measuring unidirectional pulsating currents. The amperage curve indicates the mean average value of the fluctuating load current. When the continuous current is known, the system can be checked for overheating of motors caused by abnormal voltage or loads. The recorder will also indicate whether intermittently pumped wells reach a pump-off stage by recording any decrease in load current.

Recording Voltmeter

The recording voltmeter consists of 440/110 transformer to which a recorder is attached. The advantage of this instrument is the continuous tape that records the available voltage in three second intervals for a period of several days. The power companies are plagued with intermittent high withdrawal periods resulting in low voltage on the lease, and this low voltage might not be detected if a continuous recorder were not employed. Many times when small motors have been burned out by low voltage, these motors have been replaced with larger ones on the erroneous assumption that the well load was too great. The recording voltmeter used in conjunction with the dynamometer has helped to evaluate the problem of low voltage on individual wells and leases more thoroughly.

FIG. 3. **Overall hookup** of dynamometer and hanger.

FIG. 4. **Instantaneous volt-ammeter** used to check counterbalance of pumping well.

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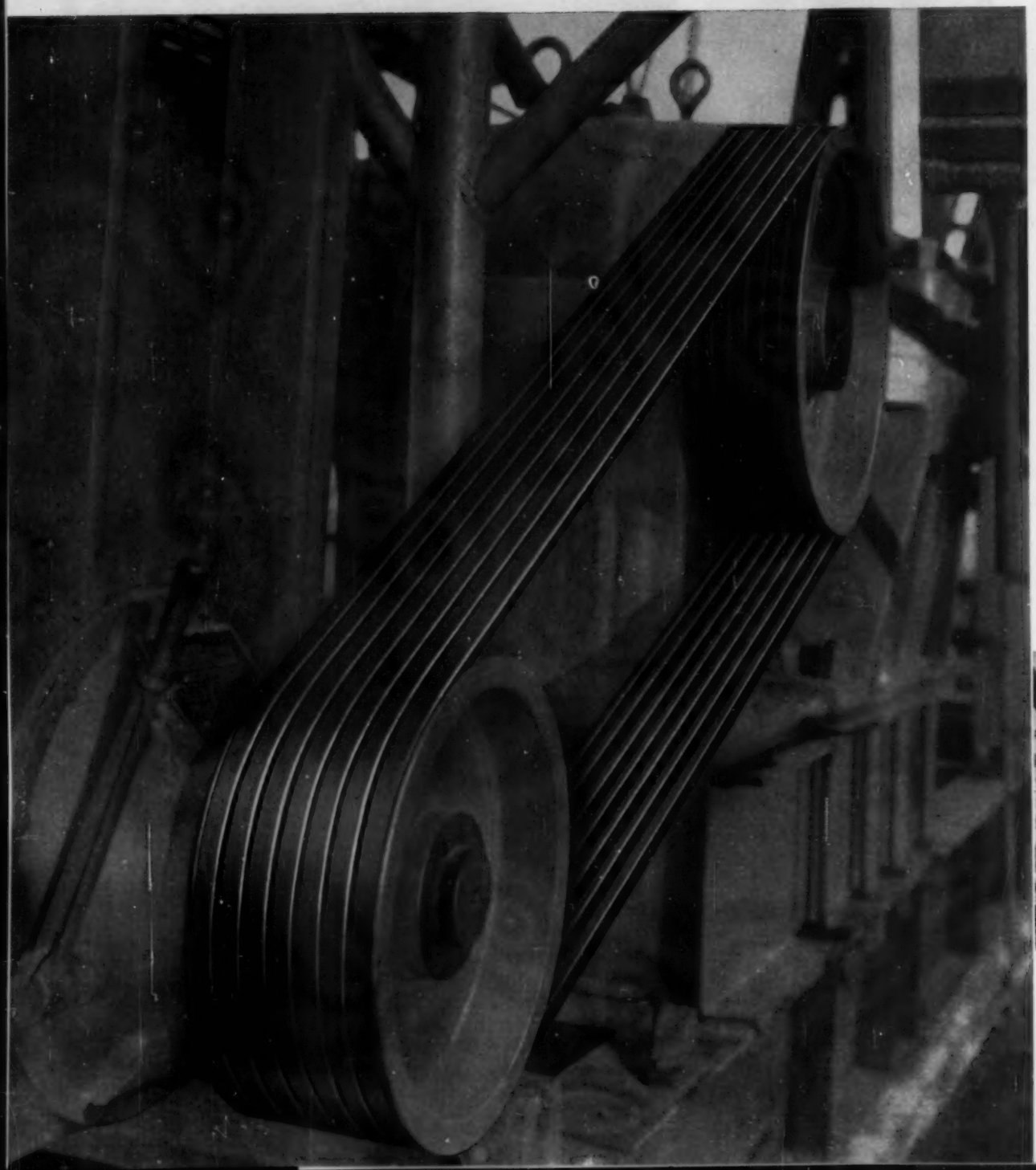

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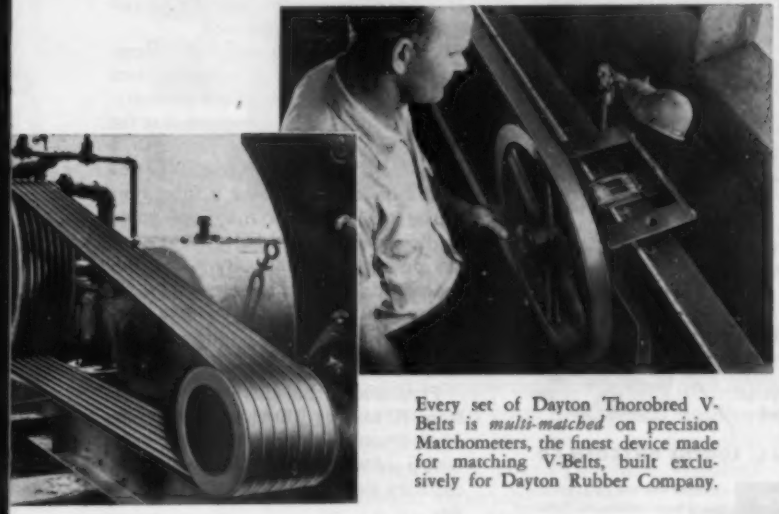

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Instantaneous Volt-Ammeter

The instantaneous volt-ammeter is used for on-the-spot checks of existing power. The ammeter also is used in counterbalancing pumping units and determining the most suitable direction of rotation.

Liquid Level Recorder

Another instrument that is used effectively is the liquid level recorder. This instrument has recently been adapted to the oil industry as a recording tank gage from its original use as a gage and control element for irrigation projects. One type recorder is a float actuated instrument that operates on tank fill-up or withdrawal, recording a continuous plot of fluid level versus time. The unit can be converted to a water production recorder by filling the float with oil so that the float will ride at the water-oil contact. The liquid level recorder aids in determining the producing characteristics of each well, and is of great value in regulating the pumping cycle for wells produced intermittently.

DYNAMOMETER ANALYSES

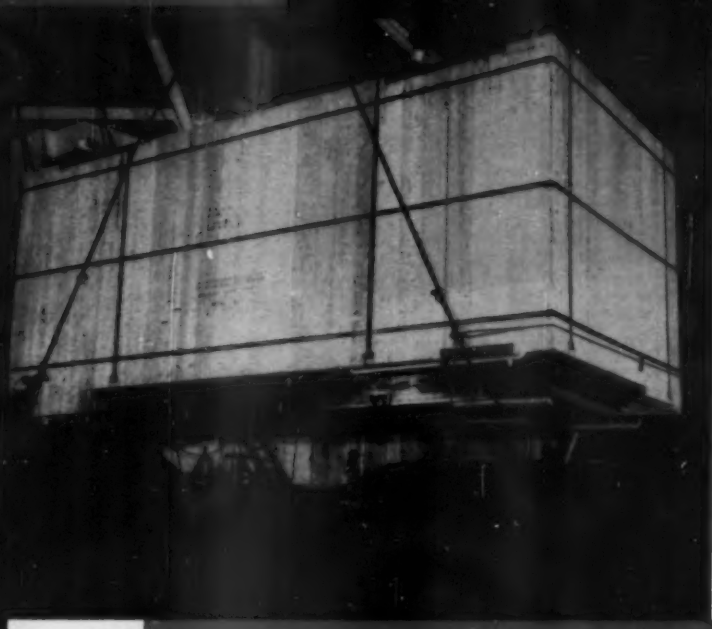
It would be a waste of time to drive up to the average problem well, record a dynamometer card, and leave the location without previously having obtained preliminary data. Therefore, the prerequisite to any dynamometer work is the gathering of details concerning the well. The data available from the dynamometer is an important part of the study process, but production and well data are equally important. Such items as depth, rod size, pump size, casing pressures, and rate of production decline are essential if testing time is to be held to a minimum and the proper information is to be obtained.

The above data are especially necessary when studying a marginal well that pumps only a few hours each day, for unless the well is investigated at the proper time, it may be found in a pumped-off condition. Such a well should be left shut in for a short time before it is weighed so that a full pump load can be recorded before it reaches the pumped-off cycle. By using this procedure, a better understanding of well conditions can be obtained.

EXAMPLE 1: Well A, 4000 ft, South Cowden field, Ector County, Texas.

Production from this well increased from 10 to over 100 bbl of oil per day after fracturing. Some months later, well production tests indicated a rapid capacity decline to 35 bbl of oil per day.

Test 1: Dynamometer cards indicated the well was pumping-off and that the pump could not pick up a full load after a temporary shutdown. The



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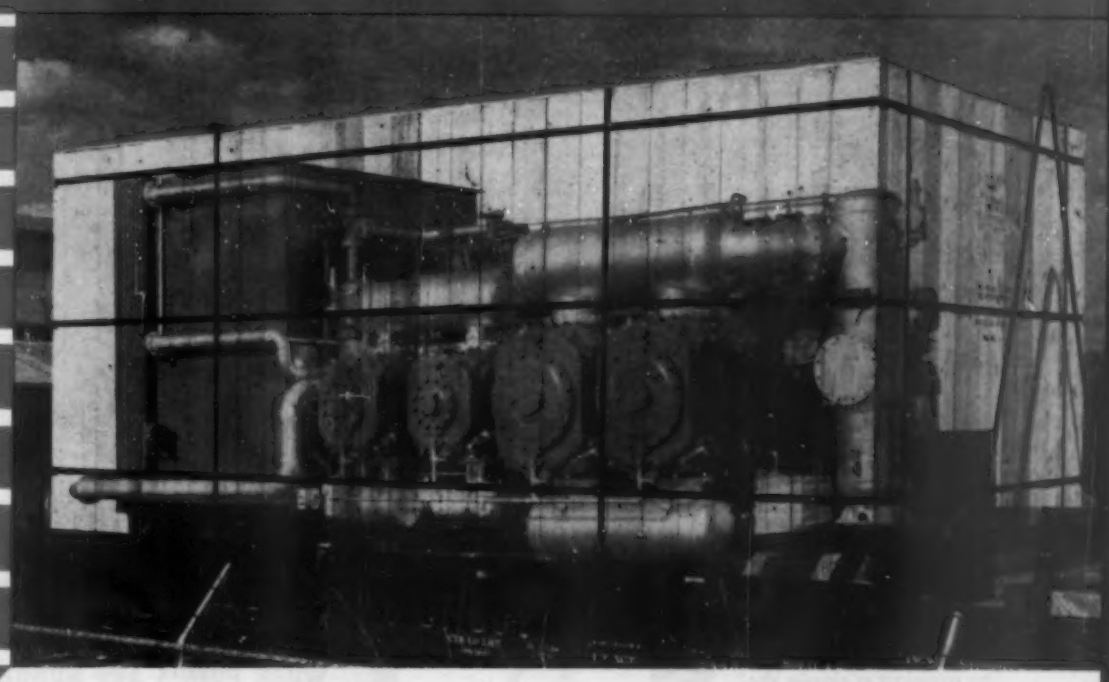

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rapid decline in production capacity was unusual and on this basis the following tests were made.

Test 2: Twenty bbl of oil were pumped down the casing annulus. Dynamometer checks showed the pump lifting a partial load and still pounding fluid. On the basis of this test, a recommendation was made to pull the rods and tubing and clean out the well.

Work: After pulling the tubing, 100 ft of cavings and bridges were found in the open hole. The well was bailed clean and returned to production.

Test 3: The well then pumped 100 bbl of oil per day, thus returning its capacity to top allowable.

EXAMPLE 2: Pumping Wells, 3200 ft, Halley field, Winkler County, Texas.

Most wells in this field are marginal; therefore, pulling work must be carefully considered. Salt bridges and sand cavings are common. Routine dynamometer tests will invariably indicate the wells to be pumped-off. A short shut-in period prior to testing will change the card to show a temporary pump fill-up followed by the expected pump-off. This short period of proper operation allows sufficient time to determine whether the valves and other parts of the pump are functioning properly. If the pump is functioning properly, the source of trouble can then be narrowed to either the anchor assembly or well capacity.

Injection of 10 bbl of water down the casing will allow sufficient fluid to check the anchor assembly. If the anchor assembly is functioning properly, the problem is attributed to a decline in well capacity.

The company assembled a portable 10 bbl storage tank that can be loaded on a gang truck. The company gang can inject water or oil in the casing annulus in a short time and the pumping operation can be checked immediately.

Tests are now being arranged to attempt to clear blocked anchor assemblies without having to pull the rods or tubing by unseating the pump and backwashing the anchor by the gravity flow of the tubing fluid. This process has been successful in low capacity wells in the Howard-Glasscock field.

These examples emphasize the fact that a drop in production should not be accepted as normal production decline just because the well pounds fluid. Equipment and procedures are available to pin-point the cause and determine the need for any immediate action.

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The Authors

C. J. Merryman is an area engineer for Sun Oil Company at Odessa, Texas. He was graduated from Louisiana State University with a BS degree in petroleum engineering. He joined Sun at Delhi, Louisiana, in 1950, and after his roustabout training, was transferred to the Odessa office as a junior engineer in 1951. He was made area engineer in 1953. He served with the Armed Forces in Europe during World War II.

B. L. Franks is a petroleum engineer for Sun Oil Company at Colorado City, Texas. He has been with Sun since his graduation from Louisiana Polytechnic Institute in 1952, when he received a BS degree in petroleum engineering. He started with Sun in East Texas and later served three years in the Permian Basin doing engineering work in production and drilling prior to his transfer to Colorado City recently.

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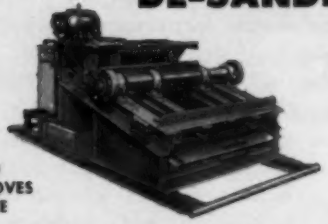

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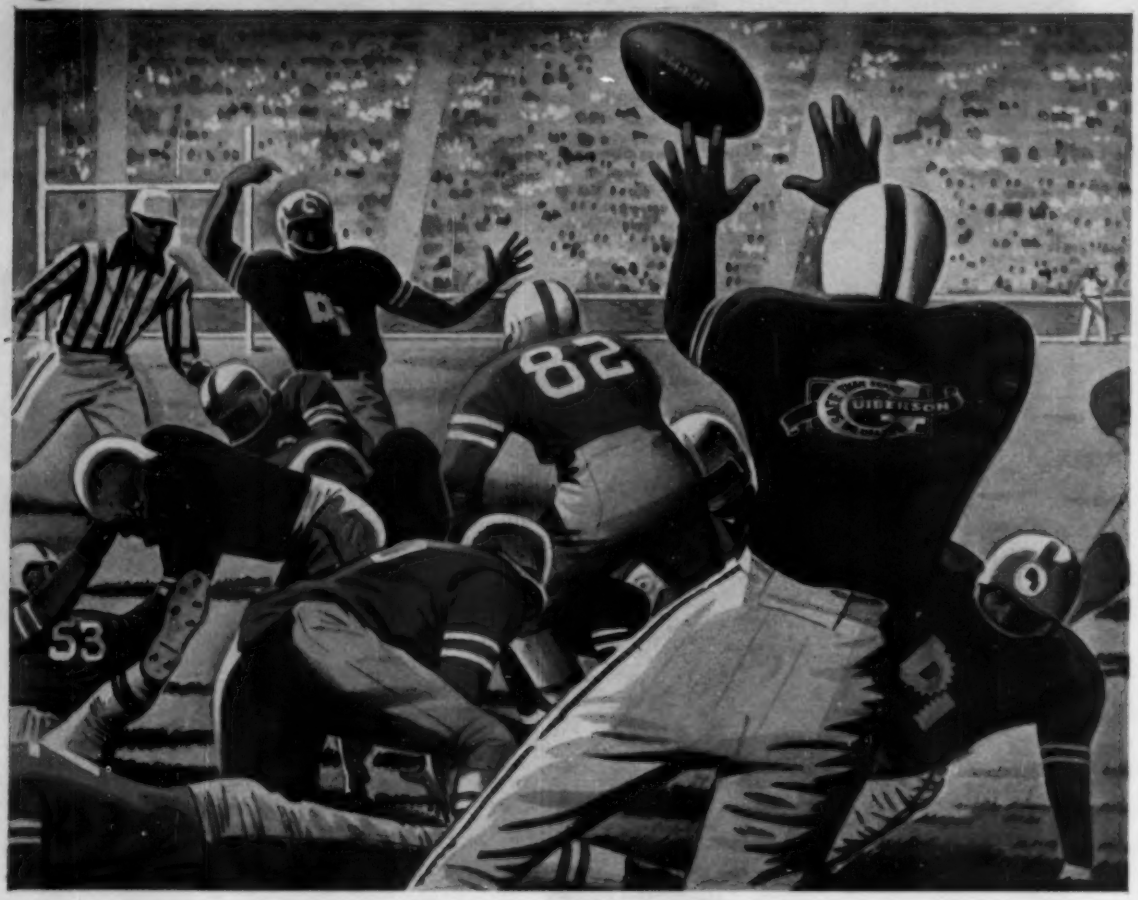

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auxiliary instruments, many lease surveys have been conducted. These studies consist of investigating the operation of surface as well as subsurface equipment. In this section, surveys on six leases with a total of 65 pumping wells will be discussed. The location of the leases varies from South Texas to the Panhandle with the Permian Basin being the center of operations.

These surveys are discussed depicting the improvements made with the aid of the dynamometer. The total reduction in annual operating costs from three of the six leases is $7884. Monthly oil production from two leases has been increased 630 bbl. The operating efficiency was increased 40 per cent on the 65 wells tested. This 40 per cent increase in efficiency was effected primarily by changes in surface operation, that is, reduced pumping time, stroke length and speed. Approximately one-sixth of the dynamometer use in the Odessa area has been consumed by lease surveys. A substantial amount of money can be saved on any pumping lease by a regular review of the operating efficiencies. There are very few pumping systems that could not be improved by applying the basic fundamentals of good pumping practices.

A. Odessa area, McCamey field, Upton County, Texas. There are 10 pumping wells on this lease which are producing oil from the Grayburg reservoir from a depth of 2200 ft. A dynamometer survey was initiated on this lease as a result of 39 pulling jobs during 1954 costing $2005.50 for contract labor alone. An additional $1162 was spent for equipment replacement during this period.

During the first year after the survey, savings on the electrical bill alone were $1800 with the pulling jobs reduced from 39 to 27. Pumping efficiencies were improved from an average of 17 per cent to an average of 66 per cent, and eight 10-hp motors were re-

TABLE 1. McCamey field, Lifting Cost Survey

	Before	After	Initial savings	Annual total
Monthly electrical cost	$340	$190		$1800
Monthly kw demand	31	20		—
Monthly kwh	17,600	9100		—
Control panels	10/2	8/1 2/2	$300	—
Lease hp	105	60	$600	—
Average pump efficiency	17%	66%		
Monthly pulling cost	$170	$100		$840
Monthly replacement mat	$100	$55		$540
Yearly rod jobs	39	27*		—
	$610	$345	$900	$3180

*Corrosion was responsible for 13 pulling jobs on one well. There should be fewer than 20 rod jobs this year — a 50 per cent reduction in the number of rod jobs. Chemical inhibition is at least partly responsible for the decline in equipment failures.

TABLE 2. A Winkler County lease, Production and Equipment Predictions

OPERATING SPEEDS	PUMP SIZE — INCHES 1¼	1¼	1½	*1¾
13.7 x 34 SPM				
Prod. (100% eff.)	61.0	84.0 BPD	123.0 BPD	165.0 BPD
Prod. (64% eff.)	44.0	53.0 BPD	78.0 BPD	106.0 BPD
A BHP (cal.)	1.9 hp	2.7 hp	4.0 hp	5 .4 hp
A BHP (actual)	1.3	—	—	—
Max. stress (actual)	15,330.0 psi	—	—	—
13.7 x 44 SPM				
Prod. (100% eff.)	78.0	109.0 BPD	158.0 BPD	215.0 BPD
Prod. (64% eff.)	50.0 BPD	70.0 BPD	101.0 BPD	135.0 BPD
A BHP (cal.)	2.5 hp	3.5 hp	5 .1 hp	6.9 hp
Max. stress	—	—	—	—
20 x 44 SPM				
Prod. (100% eff.)	115.0 BPD	158.0 BPD	225.0 BPD	315.0 BPD
Prod. (64% eff.)	74.0 BPD	101.0 BPD	142.0 BPD	200.0 BPD
A BHP (cal.)	3.8 hp	5.1 hp	7.7 hp	10.0 hp
Peak Torque	NA	NA	57,000.0 in.-lb	**65,200.0 in.-lb
Req'd. counter balance	NA	NA	4,405.0 in.-lb	4,867.0
Max. stress (cal.)	NA	NA	21,100.0 psi	24,200.0 psi

*Will require larger tubing (2½-in.)
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The 10 wells on this lease were weighed during September and October 1954, and the problem of high pumping speeds, low efficiencies and mechanical failures were studies. Necessary alterations and planned improvements were made during the following months, and the results are in Table 1.

B. Odessa area lease, Winkler County, Texas. There are four oil wells and four water injection wells on the lease under study. The wells are pumping from the Yates formation at approximately 2950 ft. Each producing well was equipped with a 57,000 in-lb unit, a 5-hp electric motor, ⅝-in. rods and 1 1/16-in. or 1¼-in. insert pump.

The usefulness of the dynamometer in the waterflood project cannot be summed up in a monetary figure alone. At the start of the flood, actual loads were measured by using the dynamometer. With this information, the maximum limits of the downhole pumps, rods, electric motors, and pumping units were calculated at various stroke lengths and speeds. Different size plunger capacities were determined showing the limits of each pump. These calculations were tabulated and used as a guide so that equipment changes could be predicted and executed as the flood developed.

Monthly dynamometer checks have been made on the four producing wells to determine if the pumps were functioning properly and if the wells were being pumped-off. Many slightly cut valves have been discovered but the wells would still be pumping-off. A slightly cut pump does not necessitate immediate replacement if it is recovering all the fluid coming into the well bore. By realizing this, the lives of many downhole pumps have been extended. Monthly fluid tests on individual wells were compared with the theoretical pump capacities. When a pump efficiency of 80 per cent or over was reached plans were made to increase pump displacements. These procedures have resulted in maximum production from the lease at minimum expense.

Presently units have been equipped with 10-hp motors, 1½-in. pumps, and ¾-in. rods. This will extend the pump capacity to over 200 bbl of fluid per day.

C. Big Spring area, Howard-Glasscock field, Howard County, Texas. In July, 1955, engineers conducted a dynamometer survey to determine the feasibility of placing individual units on their wells No. 1, 3, 4, 5, and 7 in Howard-Glasscock field. Wells No. 3 and 5, producing from the San Angelo

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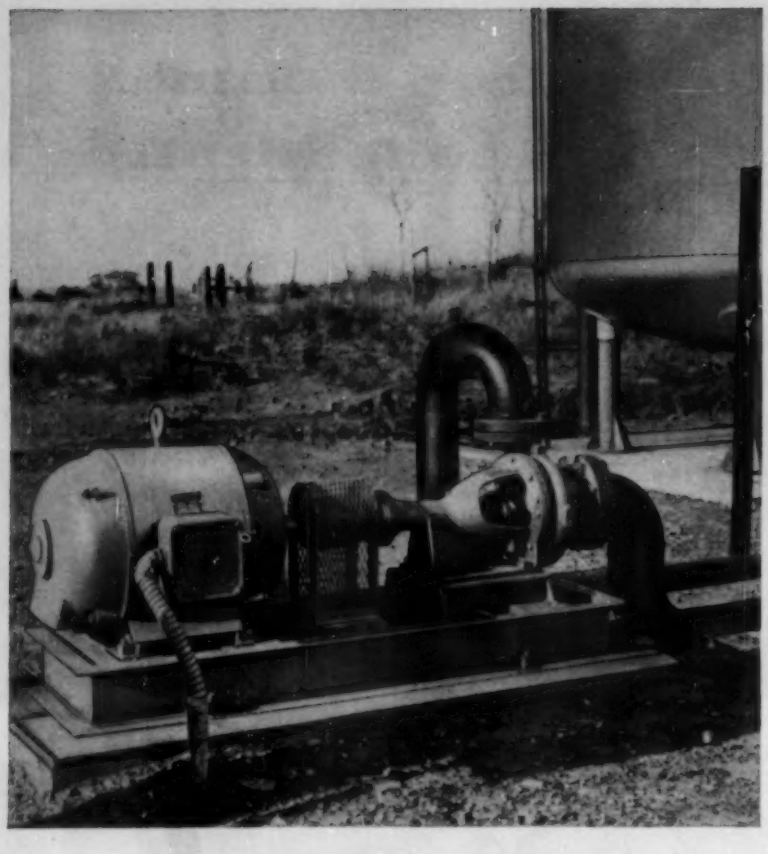

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formation, at approximately 2900 ft, were operated with rig fronts. Wells No. 1, 4, and 7, producing oil from the Grayburg-San Andres, at approximately 2500 ft, were pumped off the back side of these rig fronts with the aid of jacks. The equipment was obsolete, and replacement parts in many cases had to be made at the nearest machine shop, or obtained from a junk yard.

Rod jobs were abnormally frequent, with 30 occurring in one year on jack wells No. 1, 4, and 7. This represented 57 per cent of all pulling jobs on the eight well lease while these three wells had produced only 7 per cent of the total lease fluid.

Individual pumping units were placed on all wells. Units of the 228,000 in.-lb class were used to pump the high fluid volume. San Angelo wells, and small 38,000 in.-lb units were used on the extremely low fluid level San Andres wells. Small insert pumps replaced the old 1 25/32-in. pumps, which lifted the shallow production. The change to smaller pumps on the San Andres wells was made to reduce the peak load and to increase pump efficiency. With the larger units on the San Angelo production, the total fluid on each well has increased, with an increase in daily oil production of 29 bbl.

With individually tailored equipment for each well, operations have been more efficient and economical.

Repotential tests are filed for increased allowables on the Lease after installing larger pumping units, shown in Table 3-A.

D. Victoria area lease, Wilson County, Texas. This newly developed 13-well lease was studied in an effort to reduce the operating cost. Production was being lifted from a 1400 ft Navarro sand. Preliminary tests indicated electrical power cost could be reduced 50 per cent or $750 per year. These changes would increase the pumping efficiency from 25 per cent to 75 per cent. The cost reduction did occur; but due to the rapid decline of bottomhole pressure, production also declined. The tubing was lowered to within 15 ft of the casing perforations in order to reduce the back pressure on the reservoir, but production was not enough to warrant the expense of such a change until each well was pulled for some other reason.

Six tests were run to determine the optimum rate to produce this shallow production, and the tests are in Table 4.

Table 4 shows that test No. 4 was the most economical method of producing these wells. Even though the lease production declined rapidly the results of the survey were significant. If an engineering approach to improve

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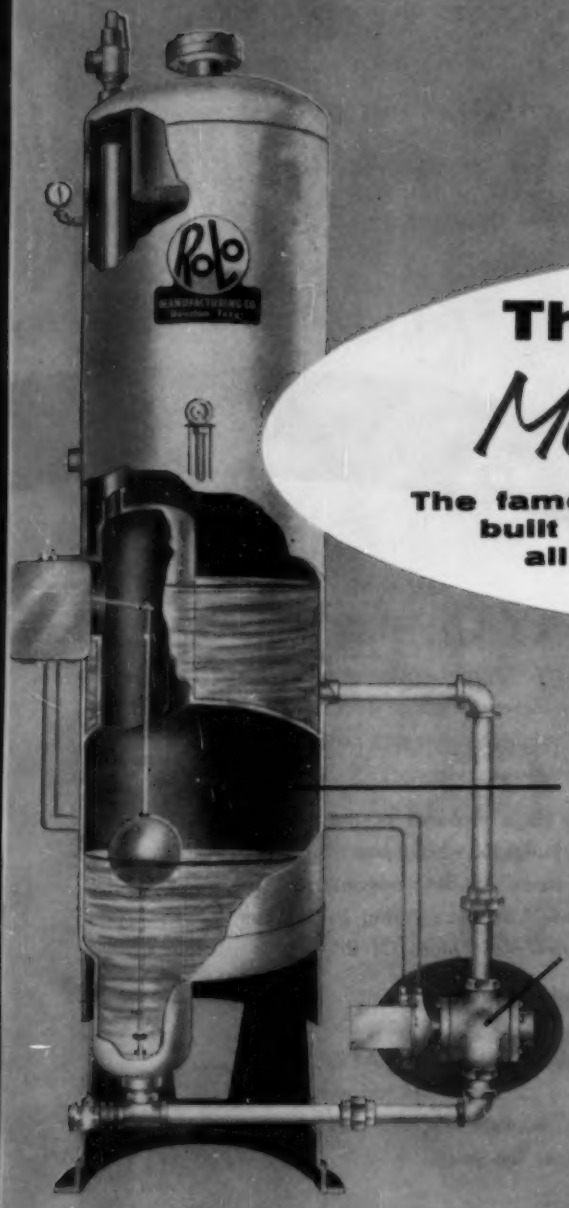

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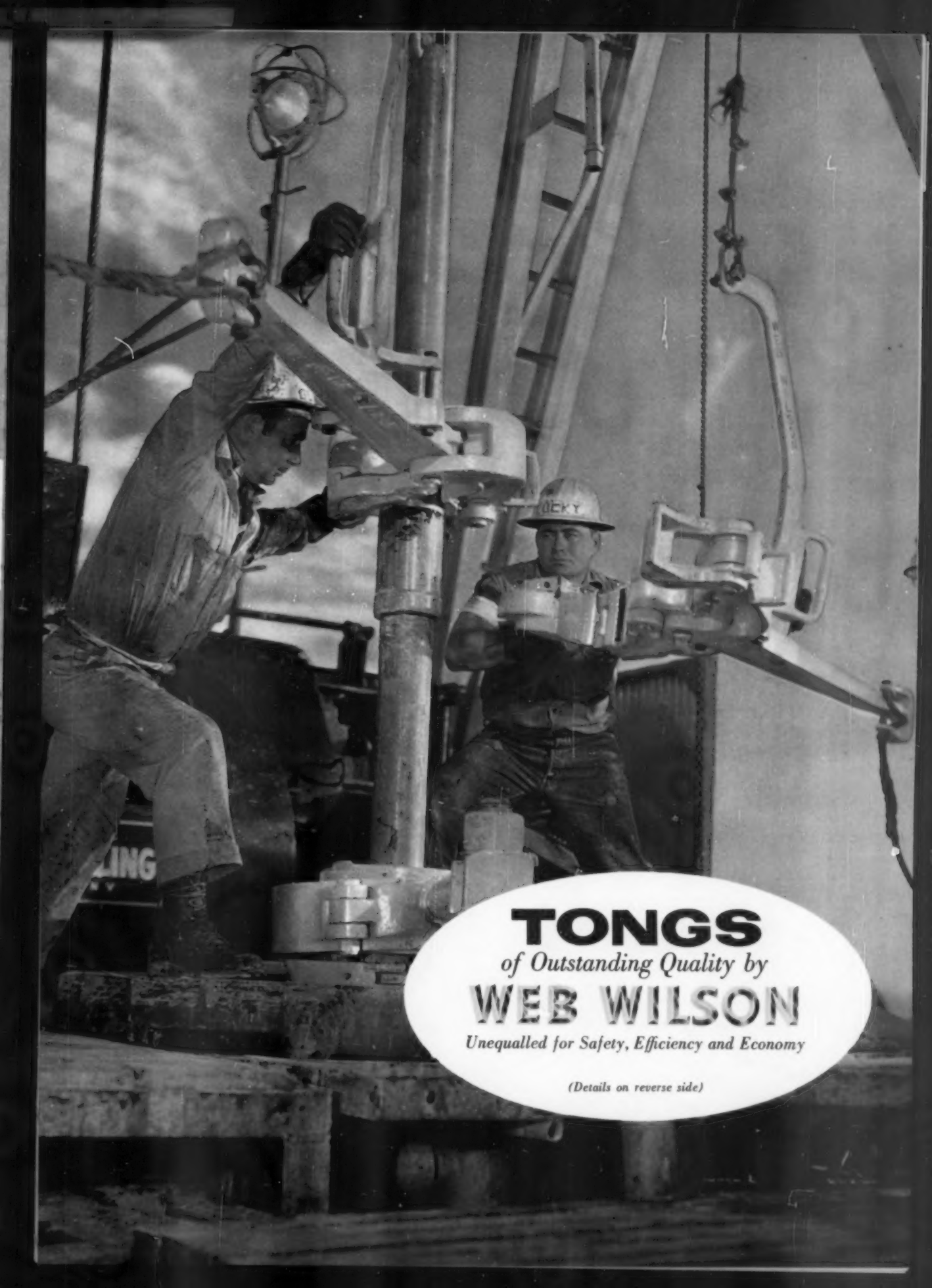
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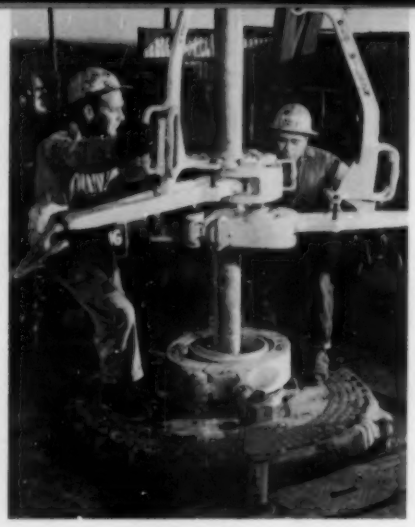

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pumping conditions is made, the optimum pumping cycle can be determined more readily. The cost to make these simple tests is nominal but the savings can be of consequence.

E. Pampa area, Panhandle field, Gray County, Texas. This survey included 25 wells on three pumping leases in the Panhandle field, Granite Wash formation at a depth of approximately 3000 ft. The average pump efficiency was 38 per cent, and the electrical lifting cost was 3.25 cents per barrel of oil. All wells were pounding fluid, with some wells operating with volumetric efficiencies as low as 9 per cent. To reduce the stress on the equipment caused by fluid pound and to increase the operating efficiency, it was recommended that paragon clocks be tested on each well.

Three wells were tested with the 96 pin clock, which allowed frequent on and off schedules. These clocks require a 440-110-v transformer installation but give a time as short as 15 min on and 15 min off, if the well requires such a cycle. The operating efficiency was increased to 76 per cent, reducing the power cost on the three wells by 50 per cent. From the results of these tests, 17 additional paragon clocks were installed. All clock changes have been made but there are still adjustments to be made in stroke lengths and speeds.

F. Big Spring area, Howard County, Texas, lease. Lease studied here consists of five pumping wells producing from the Grayburg formation at 2800 ft, with four of the five wells operating from a central power unit. The power was driven by a gas engine which was nearing retirement. The four wells on jacks were pumped once a day due to the manual operation of the gas engine. Tests had been run comparing several cycles per day versus one period. The tests indicated that an increase of 4 bbl of oil per day or 1 bbl of oil per day per well might be expected.

A surplus 25-hp electric motor was installed to serve as the driver of the central power replacing the gas engine. With the new installation the low bottomhole pressure wells were pumped more efficiently.

The results of the changeout netted an increase of 4 bbl of oil per day. Also the fifth well was added to the central power; thereby making available a surplus engine. Three hundred dollars per month will be gained with the additional oil production.

TABLE 3. Howard-Glasscock field, Lifting Cost Study

		Mo. Before	Mo. After	Mo. Savings
Company labor for repair and maintenance		$ 62.60	$ 10.00	$ + 52.50
Company labor for pulling jobs		174.00	100.00	+ 74.00
Contract pulling cost		107.00	0	+ 107.00
Material and maintenance		20.00	20.00	—
Electrical charge		260.00	300.00	— 40.00
Monthly production loss		115.00	25.00	+ 90.00
Monthly rod jobs		3.75	1.50	—
Average pump efficiency	San Andres	18%	65%	
	San Angelo	85%	96%	
Monthly increase of production	San Angelo	0	*17	+ 1245.00
	Monthly Total			1528.50

*Three wells increased in production 29 bbl of oil per day but the pipe line could not run all the additional oil.

TABLE 3-A. Well Production

	Oil	Wtr	Hours Pumped	Size Pump	LS and SPM
No. 3 Before	18 BOPD	576 BWPD	24 hr	2¼-in. pump	18-54 SPM
No. 3 After	30 BOPD	576 BWPD	24 hr	2¼-in. pump	22-54 SPM
No. 5 Before	12 BOPD	492 BWPD	24 hr	2-in. pump	19-64 SPM
No. 5 After	22 BOPD	768 BWPD	24 hr	2-in. pump	24-64 SPM
No. 2 Before	18 BOPD	396 BWPD	24 hr	2¼-in. pump	18-44 SPM
No. 2 After	25 BOPD	504 BWPD	24 hr	2¼-in. pump	18-54 SPM

TABLE 4. Wilson County lease, Lifting Cost Study

Test	B/D Total Fluid	Cost/bbl Fluid	Elec. Cost per day	Elec. Cost per year	Pumping Efficiency	Hours Pumped per day
1	5.99	$ .0328	$ .196	$ 71.54	18%	24
2	7.15	.0267	.191	69.72	22%	24
3	6.66	.0264	.176	64.09	51%	24
4	6.56	.011	.072	26.43	74%	6
5	6.39	.0178	.114	41.46	36%	9.7
6	6.30	.032	.201	73.55	19%	24

Tests were conducted as follows:
No. 1 Pumping with seating nipple 110 ft above perforations.
No. 2-6 Pumping with seating nipple 16 ft above perforations.
No. 3 Pumping with 5½-18-in. SPM (Approx. 12 bbl capacity per 24 hr.)
No. 4 Pumping on timed cycle — 15 min on, 45 min off.
No. 5 Pumping on timed cycle — 30 min on, 45 min off.
No. 6 Pumping 24 hr per day — (same as test No. 2).

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The Shaffer Oil-Sealed Jar Safety Joint offers all the "two-tools-in-one" features—and the many other advantages of the original Jar Safety Joint first developed by Shaffer years ago. It can be used in testing, fishing, diamond coring or other operations to deliver a sharp upward blow for freeing the string whenever it becomes stuck . . . and, as a Safety Joint, can be readily released in the event the string cannot be loosened.

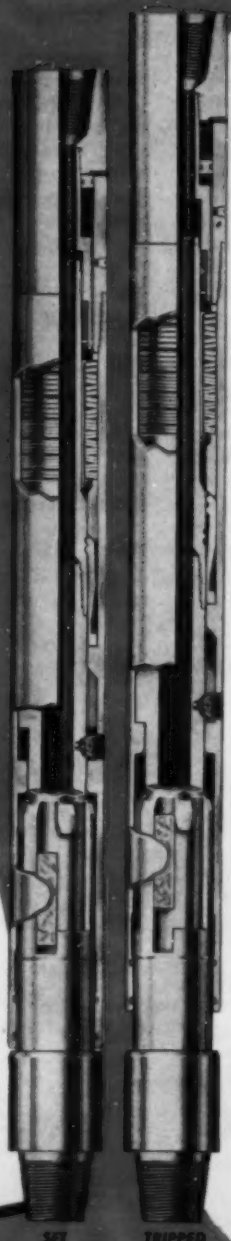
Both these operations—Jarring and Releasing—are performed under the positive control of the operator, and either action can be selected at his discretion.

MECHANISM COMPLETELY OIL-SEALED

To protect the mechanism against the corrosive and abrasive actions of mud, sand and grit, all operating parts are now sealed in a chamber filled with clean oil. At even the greatest depths and highest fluid pressures, this oil-filled chamber prevents the drilling mud from contacting the internal mechanism of the Jar Safety Joint because the oil in the chamber automatically "balances" the varying hydraulic pressures in the well so that packing units are not subjected to excessive pressure differentials.

Result . . .

1. **There is no change in "tonnage trip-off" or other characteristics as operating depths increase.**
2. **Abrasive mud, sand and grit—corrosive chemicals and salts—never contact the operating mechanism. This assures longer life, negligible maintenance.**
3. **The packing, not being subjected to excessive pressure differentials, lasts much longer and remains leak-proof at even great depths.**



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TRIPPED POSITION

Other important advantages

In addition to its Oil-Sealed design, these advantages are also typical of the Shaffer Oil-Sealed *Jar Safety Joint* . . .

- Jarring action is automatic and positive. To deliver a sharp upward blow, it is only necessary to raise the string until tension is equal to the pre-set tripping load of the tool, whereupon the blow is struck. Lowering the string again re-sets tool for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.
- Only *straight pull* is necessary to operate the tool. No torque or other secondary operations are needed—particularly important on fishing, testing and similar strings where light connections are used.
- The force of the blow is absorbed by integral knocker heads built into the tool—not by easily-damaged drive-keys or threaded elements.
- The Shaffer Oil-Sealed Jar Safety Joint does not depend upon friction for its tripping action. Therefore the tool is not subject to variable operating characteristics. Its action is dependable, uniform, fool-proof!
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TABLE 5. Panhandle field leases, Lifting Cost Study

	Before	After	Monthly savings
Monthly electrical cost	$565.00	$457.00	$108.00
Monthly kwh	38,500	31,160	7340
Average pump efficiency	38%	68%	
Material and equipment	No value assigned		

WORKOVERS AND COMPLETIONS

Value of the dynamometer cannot be overemphasized when it is used to assist in evaluation of the results of remedial well work and completions. Wherever sucker rods are utilized, application of the dynamometer can readily define production variations as being caused by mechanical failures and wear, as well as by pump capacity. In most cases, it is of the utmost importance to know if the production is being curtailed by limited or faulty equipment.

Capacity Measurements

Remedial well work is accepted as successful in most cases, if the well capacity increases to its maximum allowable. The pumping system is then considered adequate and actual well capacity tests are not mandatory. This production increase is the improvement desired; but unfortunately it is not always the result experienced. Frequently after well work the production is increased but it does not reach the top field allowable. This in-between well, which has increased in production capacity and has not reached the top allowable, immediately presents the question of whether the pump is functioning properly and handling all the available fluid. Many wells have been pulled to answer this question. Dynamometer tests will supply the answer. The problem can be attributed to the equipment or the well, and corrective measures can be considered and executed. Generally this testing can be done in less than one hour and the daily report can include both the production volume and well or pump limitations.

Example: Well A, 3000 ft; South Eunice pool, Lea County, New Mexico.

Prior to well work, the production had declined to zero and the well would only produce gas intermittently. After fracturing, a pump installation was required and the test history was as follows:

Test 1: Downhole equipment: 1½ in. pump, 1-in. gas anchor, 2½-in. tubing and mud anchor. Production: 8 bbl of oil per day, 28 bbl of water per day.

Test 2: To increase capacity installed 2¼-in. pump. Production: 8 bbl of oil per day, 32 bbl of water per day. The

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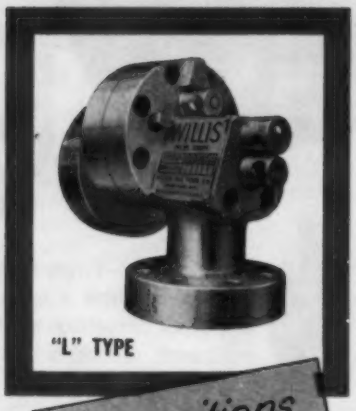

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tendency at this point would be to accept 40 bbl of fluid per day as being the well fluid capacity.

Test 3: Well was weighed and a severe gas compression curve with intermittent valve sticking was found. Pump was pulled and rerun with a rubber lined cage, double "California-type" balls and seats, 3-in. mud anchor, and 1¼-in. gas anchor. Production test: 53 bbl of oil per day, 20 bbl of water per day — top field allowable. The pump size was reduced to 1¼-in. for regular operation.

Fracturing Problems

The results from formation fracturing have been tremendous throughout the Permian Basin. Well capacities have been increased to unbelievable amounts but quite often the well's producing characteristics have changed radically. The most frequent problems materializing after fracture work are gas compression, gas lock, sticking valves, and increased loads. Sticking valves, in this instance, mean that the valves are propped open by sand or other foreign materials. The results and behavior of over 100 dynamometer tests of fractured wells involving sucker-rod pumping systems have been closely examined and not one case of sand-cut valves has

Fig. 5. **Author Merryman** rigs up dynamometer on pumping well to make check.

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been experienced. Gas locking and sticking traveling valves can easily be differentiated by dynamometer measurement. A stuck standing valve and gas lock present a greater problem in actual determination as to which one exists, but the immediate action to relieve the trouble caused by all these problems in practically all pumping systems would be to lower the pump, tag bottom, and reset for normal operation. In general, traveling valve problems are predominant. This action is probably due to the hydraulics involved when fluid moves through the pump and the velocity change past the traveling valve is the source of trouble.

Recurrence of the above problems, to the extent of hampered operations and lost production, can usually be eliminated by improvements in the pumping system. Several remedies applied in the Odessa area are as follows:

1. Reduce gas lock. Design better gas anchor-mud anchor size ratios. Relieve casing pressure and arrange positive control.
   Respace pumps. Improve pump volume ratio to production requirements.
2. Valve problems. Modify pump selection utilizing such additions as: Rubber lined cages, undersize balls, etc.
   Improve mud anchor design.
   Size pump to requirements.

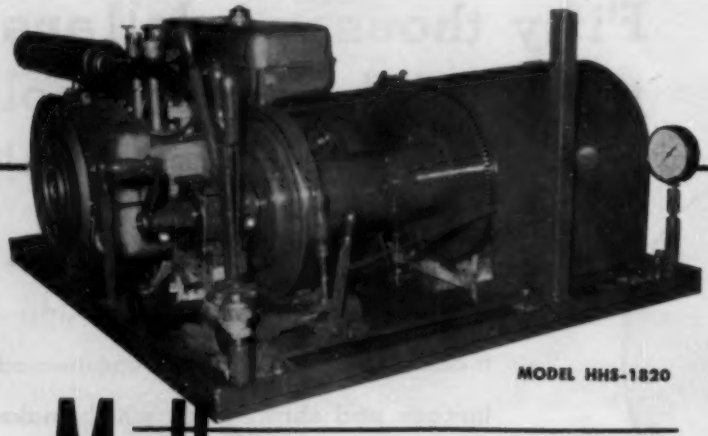
Example: Pumping Wells, 4600 ft, Means field, Andrews County, Texas.

During 1955, Sun was developing two Means field leases. On completion, each well was fractured selectively with sand-oil. Load oil was recovered efficiently with a 1¼-in. pump. Since the allowable was based on a potential factor, a 1 25/32-in. pump was run for potential test. The first well failed to pump without continuously bumping bottom. Dynamometer cards indicated that the traveling valve was sticking open. The potential test required three pulling jobs. This same pumping problem was experienced on well No. 2.

The downhole pump on well No. 3 was modified to include undersize balls and rubber lined cages. The gas anchor was increased from ¾-in. to 1-in. Well No. 3 and eight additional new wells were tested without difficulty. After potentialing, a 1¼-in. insert pump was rerun for regular operation.

Capacity problems and pumping problems after fracturing are in general the same. When primary calculations are made to determine the pump efficiency, the use of surface measurements is often relied on as a field expediency. Failure to consider rod stretch and overtravel can result in faulty interpretation of test results. Production increases often bring about load changes that can completely alter any previously existing volumetric efficiency. In numerous instances, a change in rod sizes and motor sizes will be mandatory if good production practices and satisfactory production volumes are to be maintained. This situation is most readily experienced in wells where ⅞-in. rods have afforded sufficient strength for prior operations. Relatively small changes in either strokes per minute, pump size, or stroke length are necessary to lower the downhole pump efficiency drastically. It is not uncommon to find as much as 12-in. of stroke length being lost due to rod stretch when a pump size is changed to obtain a test of well capacity. In many cases, a larger pump will not increase well production but will result in extra loading. As the effects of stimulation subside and production declines, the pump capacity should be decreased to maintain efficient operation.

Again considering problems existing in a new or reworked pumping well, the problem analysis and choice of immediate action would be simplified if the answers to the following ques-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tions were presented with notification of the problem:

a. Do any of the following exist?
   (1) Pump operation: Gas lock, sticking valves, unseated pump, leaking valves, gas compression, or low efficiency.
   (2) Rods and tubing: Tubing leak, rod part, or excessive tubing stretch.
b. Is the well pumping-off?
c. Is fluid available to the pump?
d. Is an excessive amount of casing pressure being held? If so, was the pressure bled down and what was the result?
e. Was bottom tagged and what result was indicated?
f. Will the pump pressure-up against a closed valve?
g. Does the well need pulling?

The above questions may be answered with the use of the dynamometer and a few manipulations of valves at the wellhead.

Routine Pumping Problems

As previously mentioned, a dynamometer was originally tested for the purpose of lease studies. Since the personnel were not familiar with the instrument, the regular application of the dynamometer to everyday pumping problems was considered to be a minor use.

Two years of experience have indicated that more than 85 per cent of the total application will involve tests run to evaluate individual daily pumping irregularities. With a few exceptions, a well can be reported off at 8 a.m. and the dynamometer test along with other pertinent data can be presented to the superintendent or foreman in charge by noon. The actual well test time averages only an hour. The road time to the location is usually responsible for any delay. The previously outlined testing routine is followed and necessary corrective measures are undertaken. This, of course, is made possible by the information which allows the troublesome source to be pin-pointed prior to any pulling operation.

One point that has evolved from continual use of the dynamometer is that wells on certain leases develop a particular pattern causing early failures. Once this pattern has been established, well tests and problem analyses are greatly simplified.

Generally the pumper sees all equipment installed and knows how it looks when it is pulled. His cumulative knowledge of the whole lease may date back as far as the initial completion. The pumper can furnish information concerning production as to whether a decline was gradual or abrupt, if and when production showed signs of being water-cut, and whether the tubing or casing pressures have changed. These details help solve pumping problems by a systematic process of elimination.

Any efficient test routine brings out one important factor. This factor is dynamometer availability. Lost production from testing a well to check production shortage can be tremendous if many pumping wells are involved and this lost production cannot be made up in low bottomhole pressure wells.

Acknowledgments

The writers have accumulated the factual data developed in this report by the combined efforts of all Sun Oil Company personnel. Special thanks is extended to the following for their assistance in preparing this report: Mrs. Marjorie Kroschewsky, D. K. Lawrence, J. M. Eubanks, and V. B. Cowden, all of Sun Oil Company, also Tom Smith of Sivalls Tanks, Inc., and Joe Chastain of Johnson-Fagg Engineering Company. ★ ★ ★

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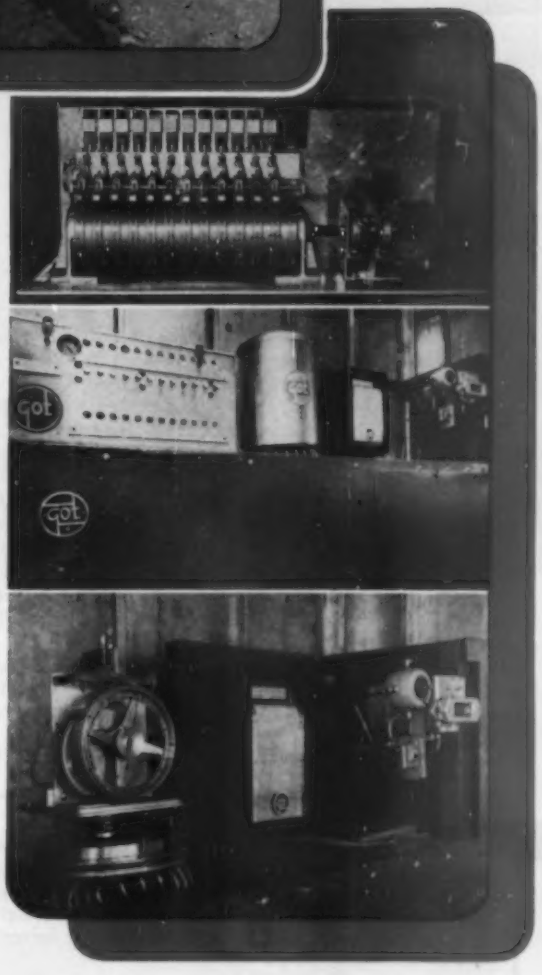

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Case Histories *A Morrow sand well drilled in Texas County, Oklahoma, showed only a rainbow on natural test. After fracturing with 15,000 gallons of T-O (1 lb. of sand per gallon), the well tested 504 B.O.P.D.* ▼ *A gas well in the Tonkawa sand in Hansford County was fractured with 10,000 gallons of T-O (1 lb. of sand per gallon). Deliverability was increased from 5,500 M.C.F. to 43,000 M.C.F.*

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Secondary Recovery Symposium Draws 1100

Reservoir and production engineers from every oil producing state in the U. S. and Canada assembled in Wichita Falls, Texas, November 19-20, for the Second Biennial Secondary Recovery Symposium. The two-day meet was sponsored by the North Texas Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Final registration for the symposium was 1100. Eleven technical papers were presented on nearly every phase of secondary recovery.

"Impact of Research on Secondary Recovery" was discussed by John Sherborne, Union Oil Company, Brea, California, pointing out the rapid development made in the field within the last 25 years.

P. S. Irvin, consulting engineer from Abilene, Texas, told of the possible economic flooding operations in fractured limestones, as proved in the lower Marble Falls limestone in the Kirk field, Comanche and Eastland counties, Texas. Irvin presented the "History and Economics of Flooding a Fractured Lime Reservoir."

"Water Flooding Pays Off on Prolific Dora Roberts Lease," declared J. D. Walters, Sunray Mid-Continent Oil Company, Tulsa, Oklahoma, in his experiences on the four-year-old Yates sand flood in the Howard-Glasscock field.

Newest of the new methods of secondary recovery was discussed in "A Field Test of the Gas-Driven Liquid Propane Method of Oil Recovery," by Loren Jenks, J. B. Campbell, and G. G. Binder, Jr., The Carter Oil Company, Tulsa, Oklahoma.

H. R. Parkison, Shell Oil Company, Centralia, Illinois, told of the hydraulically fractured treatment of water injection wells in his paper "Water Injection Well Fracture Treatments, Benton field, Franklin County, Illinois."

Two papers were presented on the selective plugging of injection wells; Wayne F. Hower and Joe Ramos, Halliburton Oil Well Cementing Company, Duncan, Oklahoma, discussed the in situ reaction, while Dr. J. N. Breston, Dresser Industries, Dallas, Texas, told of methods and field results of selective plugging.

Engineering analysis and financing flood projects were discussed by W. W. Wilson, Continental Illinois National Bank and Trust Company of Chicago, Illinois, and C. L. Brown, The Chase Manhattan Bank, New York City. A. E. Aikman, Magnolia Petroleum Company, Dallas, Texas, cited the income tax aspects of secondary recovery projects.

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EXPLORATION ACTIVITIES

TEXAS

★ Atlantic Refining Company has announced plans for drilling two more test wells in the Gulf Coast waters of Texas. The company has moved the Glasscock mobile platform "Mr. Gus" into position about one mile offshore from Matagorda County, where drilling to about 7500 ft is projected. The well (State 527S No. 1), located in 27 ft of water, will test a lease in which Atlantic has a 75 per cent interest and Tidewater Oil Company, 25 per cent. After completion of the State 527S No. 1, Atlantic and Tidewater, joined by Gulf Oil Company, will move "Mr. Gus" to Block 717, about 18 miles offshore from Aransas County. This location, which will be in 80 ft of water, will be an exploratory test designed to go approximately 9000 ft. Atlantic and Tidewater are winding up operations in Block 193, offshore Galveston Island. First efforts at this location resulted in a dry hole. A sidetrack operation is now underway in an attempt to cross a fault into a producing zone.

★ The Texas Company announced that a third Texas tidelands test well is being drilled soon at a location on State Tract 216, 1½ miles southeast of Galveston. A template structure has been set in place and the Kermac Rig 44 drilling barge of Kerr-McGee Oil Industries, Inc., will move on the well site as soon as it completes another Texaco drilling job on State Tract 136, in the Gulf south of High Island. Drilling on Tract 216 is expected to be underway by December 1, and the test is projected to approximately 8000 ft. The company's first Texas offshore wildcat was drilled south of High Island in 1955.

GERMANY

★ With the exploratory well Huttenheim 1, drilled 15 miles north of Karlsruhe, the consortium of Wintershall AG. — C. Deilmann Bergbau GmbH. has opened up a new oil deposit on the Upper Rhine. After having at first investigated two deeper horizons of the Meletta beds, which both proved waterbearing, the consortium discovered oil during a flow test from between 5260 and 5290 ft in the Cyrena marl. First production tests yielded a flowing output of 25 cu m of crude through a choke of about ⅓-in. Geologically, Huttenheim is a faulted structure in the central part of the basin of the Upper Rhine valley. This structure was located by seismic reflection surveys. A neighboring location is already being prepared for drilling.

LOUISIANA

★ Monterey Oil Company and Kern County Land Company jointly announce their discovery of an important new multi-pay oil field in La Fourche Parish, some 30 miles south of New Orleans and 12 miles southwest of the Paradis oil field. Discovery well, Monterey-Bowie Lumber Company No. 1, was completed in a 40 ft oil sand section, through perforations between 12,701 and 12,713 ft. On a 6-hour test it flowed through a 7/64-in. choke at a rate of 228 bbl a day of 41 deg oil and 935,000 cu ft of gas per day. Pressure on the tubing was 6600 psi. In addition to the 40 ft oil sand section from which the well is producing, eight more oil and condensate sands were located between 9400 and 13,368 ft. These vary in thickness but amount in total to 132 net feet. Monterey-Bowie Lumber Company No. 1 is near the middle of an 11,300 acre lease block in which Monterey and Kern County Land hold jointly a 50 per cent interest. Location for a second well has already been staked about 4000 ft west of No. 1 and drilling will begin immediately.

★ An exploratory well from which the operators expect to produce gas with surface pressures of perhaps 10,000 psi is being drilled by Tidewater Oil Company, et al, in the Church Point Field of Acadia Parish. The test, Tidewater's No. 1 H. Thibodeaux, is spotted 1500 ft southeast of Tidewater's No. 1 Diagle, drilled two years ago, which tapped a 14,500-ft gas and distillate sand with a bottom-hole pressure estimated in excess of 13,000 psi. The well was plugged back and completed uphole because the operators and their associates did not feel it safe to complete in the high pressure zone with the equipment then available. Modern metallurgical advances have now developed pipe sufficiently strong to control the high pressures, the operators feel. The test is in Section 83, T8s, R2e, in Acadia Parish, two miles south of the town of Church Point and some 20 miles northeast of Crowley. Tidewater has some 2500 acres in the area.

COLORADO

★ Jack Rouse and Don M. Rounds have completed a flowing oil discovery well 10 miles east-northeast of Denver. Well is on the Derby Dome in Adams County in the Denver-Julesburg Basin. Wildcat topped the first Dakota at 8298 ft, drilled to 8453 ft, and perforated casing at 8300-09 ft. Following hydrafrac treatment, well flowed an estimated 500 bbl per day. Well is shut-in for tankage and operators are drilling a west offset.

KARACHI

★ A small show of gas has been encountered while drilling at Pakistan Petroleum's first test well at Karachi. The show occurred at a depth of 5976 ft when the well entered a new formation; there were no signs of oil. Drilling continues and the well is planned to go to about 10,000 ft in a full test of petroleum possibilities of this area.

UTAH

★ Two Paradox tests are slated west and northwest of Blanding in San Juan County as a result of drilling commitments made in a lease farmout to Harris Clark. Farmouts were given by Three States Natural Gas Company on two lease blocks totaling 57,000 acres. Clark has assigned one of the blocks to Stanolind, this is known as the Lime Ridge unit in T34s and 35s, R18e and 19e. Clark plans to drill the second block of 36,000 acres in T36s, 20e and T37s, R20e.

OKLAHOMA

★ Livingston Oil Company's Kirby No. A-1, in NW¼ NW¼ NW¼ section 8-25n-4w, Grant County, found a new Mississippi Chat zone from 5200 to 5227 ft. Well was perforated at 5202-09 and hydrafraced with 7500 lb of sand and 7500 gal of load oil. After all load oil and frac oil were returned, the well flowed 33 bbl per hour on 32/64-in. choke during a 3-hour test.

★ An-Son Petroleum Corporation will use its own rig to drill a rank wildcat 13 miles southeast of Buffalo and 5½ miles due west of Salt Springs, in Harper County. The well, staked as the No. 1 Lockhart, in C SW SW of 31-27n-20w, is planned as a Mississippian test with a projected depth of 6500 ft. No. 1 Lockhart is about two miles northeast of Roland S. Bond No. 1 Lockhart-Adams, abandoned in December, 1954. The dry hole was carried to a depth of 6450 ft, topping the Chester at 6105 ft.

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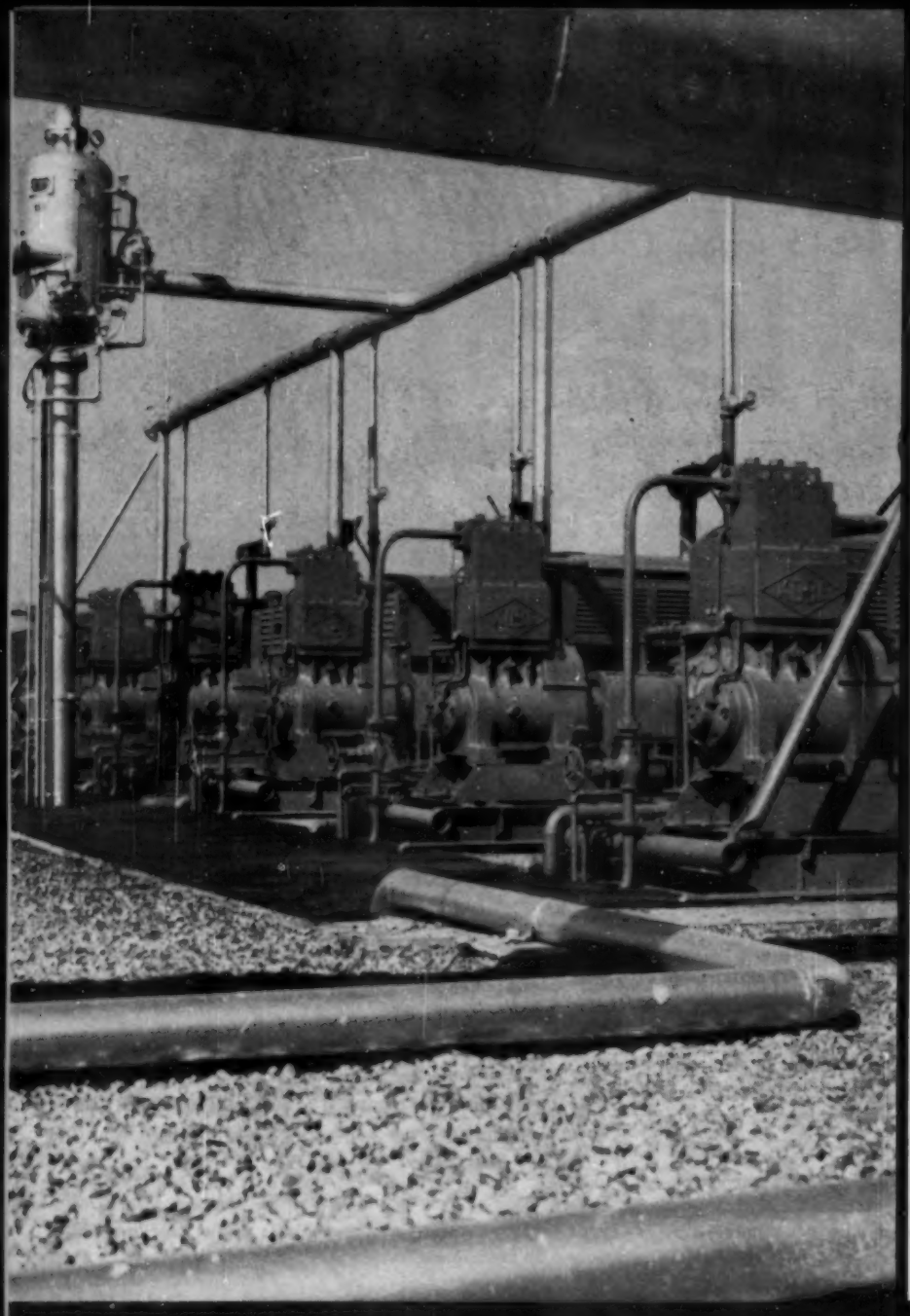

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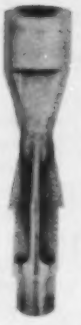

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OKLAHOMA

★ In the Panhandle, Keating Drilling Company has tested 176 bbl of load oil and 4,500,000 cu ft of gas per day at its No. 1 Dunn, 8½ miles northwest of the Northwest Lavern field and 1½ miles east of the Beaver County line. The gas discovery is in the Morrow, with perforations at 6364-72 ft and flowed on test through a ¾-in. choke. Testing is continuing. Well had drilled to the Chester, where a test, following acidizing, made 1,790,000 cu ft of gas per day with some water. Well was then plugged back to 6398 ft for the Morrow tests.

PHILIPPINES

★ First phase of an airborne magnetometer survey for San Jose Oil Company of Manila, covering nearly 2,500,000 acres in the Philippines, is nearing completion. The aerial search for oil is being performed by Aero Service Corporation, Philadelphia. Flying of the survey began in mid-June. It is the largest survey of its kind performed in the Philippines and covers more than a dozen separate concession areas on the islands of Luzon, Panay, and Mindanao. Principal areas undergoing survey include the central valley of Luzon, southwest of Cagayan Valley; nearly all of Panay Island; and the Cotabato and Davao-Butuan regions of Mindanao. An interpretation of the aerial magnetic data is being prepared by Aero Services' geophysicists under the direction of Dr. Wm. B. Agocs for further analysis and evaluation by San Jose Oil Company's exploration staff. Magnetic maps of the areas will be compiled by Aero at a 10-gamma contour interval.

KANSAS

★ Livingston Oil Company completed two wells in the new extension of the Huffstetter pool, Phillips County. The No. 2-A Stahn, in SW¼ NW¼ SW¼ Section 16-1s-18w, perforated three zones in the Kansas City-Lansing formation at depths of 3364-3372 ft and 3372-3377 ft in "B" zone, 3387-3392 ft in "D" zone. After acid and load oil returned, the well swabbed 127 bbl of new oil in 9 hours.

Lutjeharms No. 1, in SE¼ SE¼ SE¼ Section 17-1s-18w, perforated zones at 3346-3351 ft in the "B" zone, 3362-3368 ft in the "D" zone and 3382-3387 ft in the "E" zone. After acid and load oil returned, in 6 hour test, the well swabbed 17 bbl per hour.

★Lion Oil Company has completed the Marion No. 1 as a gas discovery well in Meade County. The wildcat produced gas at the rate of 4,890,000 cu ft per day through a 30/64-in. choke.

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What's doing in DRILLING

★ **Deepest hole in New Mexico** has been completed as a Pennsylvanian discovery at 11,316-52 ft. Phillips Petroleum Company carried the well, its No. 6 Leamex, to 16,842 ft in the Pre-Cambrian. The well, 25 miles southwest of Lovington and 2 miles southwest of the shallow Maljamar pool in Lea County, produced 264 bbl of 37 deg oil on completion test. Gas-oil ratio was 1061 to 1. Although the deepest, the Leamex is not the deepest producer.

★ **Drilling contractors** not attending AAODC's eleventh annual Drilling Safety Clinic missed the most instructional sessions ever held, observers declare. The meeting, held in Dallas, Texas, November 8 and 9, drew about 150 contractors, safety engineers, and drilling superintendents. Principal speakers were Joe Zeppa, Delta Gulf Drilling Company; Sam Oliphant, Tennessee Gas Transmission Company; Col. Homer E. Garrison, Jr., director of the Texas Department of Public Safety, Charles B. Wallace, Magnolia Petroleum Company; R. C. Tucker, Great Western Drilling Company; J. H. Massie, Jr., Lowe Drilling Company; W. H. Archer, Southeastern Drilling Corporation, and J. C. Magner, Rowan Drilling Company.

★ **Texas drilling contractors** have been notified that a 7 cent per $100 payroll reduction in the manual rate for workman's compensation insurance has been approved by the state Insurance Department. The $100,000 per year saving to the industry "has come about through the actions of contractors themselves in becoming more conscious of insured losses," insurance consultant Joseph M. Shelton told the AAODC. He also pointed out the reduction in the manual rate for drillers contrasts with the 1.3 per cent increase for oil classes generally. Rates are based on the two previous years' experience. Drilling contractors' safety records have caused a steady decline in workmen's compensation rates from $10.05 per $100 of payroll in 1952 to the newly established rate of $8.59.

★ **Utah drillers** can't be accused of pulling bits green, as shown by the remains of a 3⅞-in. tri-cone. The bit made only 10 ft of hole in the hard Dakota formation in Three States Natural Gas Company's M. D. Kearns No. 3 in Emery County. The well, contracted by Great Western Drilling Company, was being air drilled into the productive formation between 7550-7560 ft. Air was used to blow water from the hole and to make 10 ft of hole. The hard formation bit, last one on the rack, was in the hole about 18 hours. Long supply lines had detained new bit delivery to the well, one of Three State's Clear Creek units high on the Wasatch Plateau; the kelly was to be kept "turning to the right" until new ones arrived. Bit was pulled, however, when air circulation was finally cut off. Operators believe the bit was actually worn, not broken, since the followup bit went straight to the bottom and encountered no junk in the hole.

★ **Drilling success ratio** for Sunray Mid-Continent Oil Company has been 72.5 for the first nine months of 1956. Ratio is based on both exploratory and development wells drilled, and represents a 4.5 per cent rise over the same period last year. The company's exploration department drilled or participated in the drilling of 107 net exploratory wells during the period with a discovery ratio of 28 per cent.

★ **$250,000 bonus** posted by the State of Georgia for the operator getting the first commercial well in the state may be taken by J. R. Sealy. Sealy, the only operator now drilling in Georgia, is making hole on the No. 1 Seminole Naval Stores Company in Seminole County. The well has already broken the state's drilling depth record of 7487 ft set in 1944. Sealy set protective casing at 5600 ft and was last reported drilling below 7518 ft. Well is in the center of lot 14, land district 21 in the southeastern part of the county.

★ **Deep water drilling barge** is under construction for the newly-organized Universal Drilling Company, Inc., New Orleans, Louisiana. The firm will enter the contracting business with the one barge, an advanced design unit for operation in waters up to 120 ft deep, to be used along the continental shelf of the Gulf of Mexico. Universal will be directed by Louis J. Roussell as president. Roussell, an oil operator, has worked three years designing a new type hydraulic jack to be used on Universal's new unit.

★ **California drillers** won't be able to meet the record set in the state last year. In the first 11 months of 1955 a total of 2172 holes had been drilled, while this year's record to date only indicates 1986 tests. Notices to drill in California in the first week of November were off from the same date last year, 46 against 55.

★ **Permian Basin drilling depth record** has been set at Gulf Oil Corporation's No. 1 P. G. Northrup, 24 miles southeast of Pecos in Reeves County, Texas. Well is bottomed at 18,771 ft with a projected depth of 19,200 ft. Gulf has lost circulation at present depth. Former depth record was set at the Hunt Oil Company No. 37 Elsinore Royalty, Pecos County, drilled last year.

★ **The T-L Drilling Company, Inc.,** has been formed in Houston, Texas, by two veteran oilmen, W. P. (Foots) Larkin and J. C. Traylor. Larkin has held supervisory positions with both contractors and independent operators for the past 17 years. Traylor comes into the company with 25 years of service with a major oil company and a major service company.

★ **Sixth rig** has been put into operation in Oklahoma for Reed Drilling Company, Tulsa. Newest unit is a 4500-ft rig recently purchased from Shenandoah Drilling Company. Rig 6 is now operating in T9N-R7E in Seminole County. Other operations are in Tulsa, Seminole, Noble, and Grant counties.

★ **New offshore contract drilling organization** has been formed by a group of Houston, Texas, oil operators and marine contractors. To be known as Mobile Offshore Company, the firm has let the contract for its first submersible barge to be delivered next June. The unit is self-contained and operates on the same principle as a floating dry dock. Height of unit from base of the hull to the deck will be 110 ft; hull dimensions are 201 by 203 ft. The barge will drill as many as eight wells in one location.

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These instruments have their own generators that transmit low-voltage signals through electric cords to meters installed wherever you need them.

MULTIPLE METERING IS SIMPLE

Now you can have meters as far from the take-off points as you need. You can also have several meters getting their signals from a single source, or a grouping of several meters, each getting its signal from a different pump or engine—or you can have both. Additionally, you can have a simple recorder to make a permanent record of these operations.

CALIBRATE RIGHT ON THE RIG

You can move these instruments from rig to rig, with little concern about the gear ratios used. The pump-stroke tachometer and the rotary-table tachometer each has a screw adjustment that allows you to calibrate the instrument right on the rig. Thus, you don't have to stock different types of tachometers for different types of engines and different types of rotaries.

GET THE FACTS TODAY

Find out how the new design in tachometers can revolutionize the instrumentation on your rig. Write for free literature from the Martin-Decker Corporation, 3431 Cherry Avenue, Long Beach 7, California.

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HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Oct. 15	Oct. 22	Oct. 29	Nov. 5	Nov. 12
Alabama	8	9	8	8	10
Arkansas	20	19	18	18	16
Arizona	0	1	0	0	0
California	117	114	105	111	111
Colorado	64	70	74	65	64
Florida	4	4	4	4	2
Georgia	0	0	0	0	0
Illinois	77	73	61	77	62
Indiana	14	9	13	7	12
Iowa	1	1	1	1	1
Kansas	172	174	170	167	171
Kentucky	8	10	14	8	11
North Louisiana	62	72	73	71	69
South Louisiana	359	373	370	382	387
Total Louisiana	421	445	443	453	456
Maryland	0	0	0	0	0
Michigan	17	16	18	15	16
Missouri	1	1	1	1	1
Montana	48	48	46	41	39
Mississippi	32	28	28	29	26
Nebraska	28	24	24	22	24
Nevada	1	1	0	1	2
New Mexico	131	131	128	129	128
New York	0	0	0	0	0
North Carolina	0	0	0	0	0
North Dakota	24	23	25	27	27
Ohio	1	1	1	0	0
Oklahoma	274	258	250	258	252
Oregon	0	0	2	0	0
Pennsylvania	8	6	6	6	7
South Dakota	0	0	0	0	0
Tennessee	0	0	0	0	0
Texas Gulf Coast	239	245	239	235	250
West Texas	375	369	381	383	385
North Texas	305	310	316	322	322
East Texas	68	61	60	62	61
Total Texas	987	985	996	1002	1018
Utah	28	30	28	27	29
Washington	1	1	1	1	1
West Virginia	3	2	3	3	3
Wyoming	75	69	69	61	69
United States	2565	2553	2537	2542	2558
Western Canada	236	225	234	252	252
Grand Total	2801	2778	2771	2794	2810

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

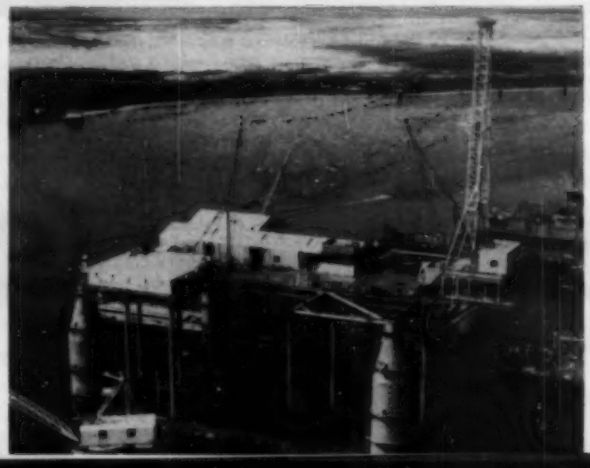
Kermac Commissions Rig 46; Rig 47 Moves to Completion Site

Kerr-McGee Oil Industries' new mobile offshore drilling Rig 46, still fresh from commissioning ceremonies October 24, is already in service out in the Gulf of Mexico. Rig 47 has been assembled and has made its way from Orange, Texas, through the Gulf and into the shipyards at Pascagoula, Mississippi, to add finishing touches.

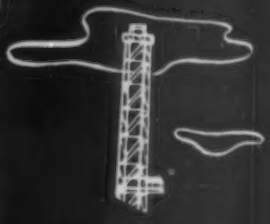
Another Kermac offshore vessel, Rig 49, is being planned.

Rig 47, identical to Rig 46 shown here at commissioning ceremonies, incorporates a unique design—a barge hull built as a gridwork of tubular cross members. The units are 202 by 242 ft in size and have four stabilizing steel columns 14 ft in diameter on the corners of the hull. When equipped the barge and drilling mast will measure 250 ft from top of the crown block to the ocean floor.

Barge members were assembled in two sections in Orange, Texas, floated past Port Arthur, down the Sabine and Neches rivers, across the open Gulf (units too large for the Inter-Coastal Canal) and around the mouth of the Mississippi to Pascagoula. Rig 47 is designed to drill six wells in one location in 70-ft waters, providing for a 50-man crew.



THE ALL NEW Wilson super giant rig



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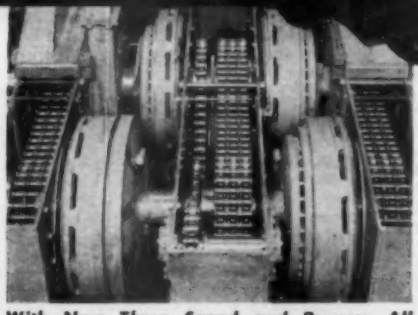

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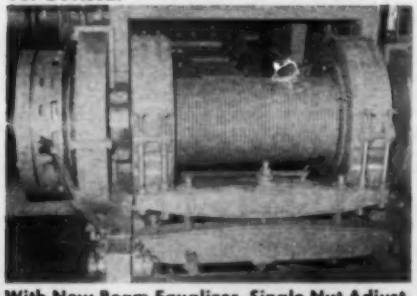

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RUNNING TOUR with MEN in the INDUSTRY

James M. Davis has been appointed drilling superintendent in Okemah, Oklahoma, for Reed Drilling Company. He has been connected with the oil field business in Texas and Oklahoma, and with Reed Drilling for the past year.

J. M. Davis

J. D. Stahl

James D. Stahl, Houston, Texas, district petroleum engineer for Union Producing Company, has been appointed field drilling and production superintendent. **Ervin O. Veselka,** the company's field drilling and production superintendent at Houma, Louisiana, will succeed Stahl as district petroleum engineer.

Stahl went to work for Union in 1941 and Veselka began working as a petroleum engineer in 1948.

Also announced was the transfer of **Murray B. Quigles, Jr.,** district petroleum engineer for Union Producing Company at Jackson, Mississippi, to Houston and promotion to assistant drilling and production superintendent. Quigles went to work for the company as a production engineer in 1946. He formerly has been district petroleum engineer at Jackson.

A. E. Chester, production vice president for Magnolia Petroleum Company, has been named general arrangements committee chairman for the 1957 spring meeting of the Southwest district American Petroleum Institute division of production. The meeting will be held in March in Dallas, Texas.

Thirteen directors have been elected to the 25-man board of the Alberta division of the Canadian Petroleum Association.

Elected for a one-year term was **G. L. McMahon** of Pacific Petroleums Limited. Elected to hold office during a two-year period were the following: **E. C. Babson,** Union Oil Company of California; **A. E. Feldmeyer,** Canadian Superior Oil of California Ltd.; **J. P. Gallagher,** Dome Exploration (Western) Ltd.; **G. H. Galloway,** Stanolind Oil & Gas Company; **W. H. Hohag,** Banff Oils Ltd.; **Dr. W. C. Howells,** McColl-Frontenac Oil Company, Ltd.; **C. A. Nabors,** Parker Drilling Company of Canada Ltd.; **N. W. Nichols,** Great Plains Development Company of Canada Ltd.; **T. Nitescu,** Canadian Fina Oil Ltd.; **J. G. Spratt,** Triad Oil Company Ltd.; **S. Stewart,** Richfield Oil Corporation; and **J. B. Webb,** Canadian Oil Companies, Ltd.

Raymond-Claude Foex has been appointed manager of Molasse Oil Exploration Company, Ltd., Zurich, Switzerland. **Bruno Muller** has been named prokurist of the company.

John F. Tolleson was formerly manager but has resigned to open his own offices as a consulting petroleum geologist.

Souris Valley Oil Company Ltd., Winnipeg, Canada, has announced **H. G. Bagnall** has been re-elected president of the company. The resignation of **Ralph Will,** Calgary, director and vice president, has been accepted.

Also announced was the election of the following directors: **H. L. Carnahan,** Slidell, Louisiana; **D. D. Ewart,** Montreal, Canada; **R. W. Kelley,** Winnipeg; **W. M. Luthy,** Calgary; **H. S. Scarth,** Queens Counsel, Winnipeg; **E. G. Smith,** Montreal.

L. A. Bal has been appointed division land man of the Ohio Oil Company's Casper (Wyoming) production division. He succeeds **R. L. Fillner,** who retired in November after 35 years service with the company.

Bal joined Ohio Oil in 1929. An Ohio Oil employee since 1922, Fillner has been in leasing and land work since 1928.

Humble Oil & Refining Company has announced the following personnel changes in its production department recently:

J. E. Willingham, Jr., senior petroleum engineer, Southwest Texas division office at Corpus Christi, Texas, to supervising petroleum engineer; **G. B. Sutton,** junior petroleum engineer, Southwest Texas division office, to associate petroleum engineer of Stratton district at Kingsville, Texas, to petroleum engineer; **R. C. Barbour, Jr.,** petroleum engineer, Athens, Texas, district, to district petroleum engineer of Imogene district at Jourdanton, Texas; **Charles B. Corley, Jr.,** senior petroleum engineer, East Texas division office at Tyler, Texas, to the Houston office petroleum engineering division as senior petroleur engineer; **Jack C. Van Winkle,** farm boss, London district, at Nacogdoches, Texas, to the Castaic Junction district, Newhall, California; **A. E. Joens,** district petroleum engineer, Tomball district, to the Houston office petroleum engineering division as senior petroleum engineer; **R. M. Hunt,** petroleum engineer, Houston office petroleum engineering division to the Gulf Coast division office; **Denver R. Langston,** part-time rotary driller, to full-time rotary driller at Andrews, Texas; **R. C. Jabusch, Jr.,** part-time rotary driller, to full-time rotary driller at Grand Isle, Louisiana; **R. R. McCarty,** who has been on a training assignment, to Corpus Christi as assistant division superintendent of the Southwest Texas division, and **D. A. North,** senior petroleum engineer, Houston office petroleum engineering division to the Hobbs district in New Mexico as district petroleum engineer.

Dr. Paul D. Torrey, petroleum engineer and geologist, president of Orchem Corporation, Austin, Texas, has been appointed lecturer in petroleum engineering at the University of Texas. He is an authority on secondary recovery, promoting studies and publications on secondary recovery of oil, which brought forth two editions of the distinguished work "Secondary Recovery of Oil in the United States." Dr. Torrey received his bachelor's degree in petroleum engineering from the University of Pittsburgh and his doctorate from Marietta College.

G. C. (Chuck) Elmer has joined the ranks of the independent oil operators in Midland, Texas. He resigned a position as division landman for Coronet Oil Company to "go on his own." His offices will be at his residence until downtown space under construction is completed.

J. D. Goodrich has been appointed production manager of the Tulsa, Oklahoma, exploration and production area of Shell Oil Company. Goodrich will assume his new position in the spring of 1957 upon the completion of a special assignment in the company's head office in New York, where he is now manager of mechanical engineering.

A. G. Copeland will take over as manager of production, filling a vacancy created by the recent death of **W. H. Burke.** Copeland has been chief exploitation engineer of the Tulsa area for the past four years. He will be succeeded in that position by **R. E. Clark,** now production manager of the Kansas division.

Robert Evans has been named geologist for Jet Oil Company, Sparta, Illinois.

Wallace L. Hammer has announced the opening of new offices as a consulting petroleum engineer in Abilene, Texas. His specialization will be evaluations, property management, well completions, and water flood operations.

W. L. Hammer

He graduated with a BS in petroleum engineering from Texas University in 1951.

Previously he has been with Stanolind Oil and Gas Company, Odessa, Texas, Abilene Sample Log Service, and Russell Engineering, both of Abilene.

Harold M. Seeley, district geologist for Seaboard Oil Company in Corpus Christi, Texas, has been transferred to Dallas, Texas, as supervisor of the Gulf Coast area. **Robert W. Luker,** formerly of the company's Dallas office, will succeed Seeley at Corpus Christi.

Frank R. Robertson, farm boss with Stanolind Oil & Gas Company, has been transferred from Brush, Colorado, to Worland, Wyoming.

Hugh D. Miser, veteran U. S. Geological Survey geologist, has been elected to honorary life membership in the Oklahoma City Geological Society. He is the only non-Oklahoman to be so honored.

Charles C. Conrad, of Sinclair Oil & Gas Company, has been promoted to assistant district production foreman and has been transferred to Odessa, Texas, from Gladewater, Texas. **Charles A. Shaid,** district production foreman at Hobbs, New Mexico, has been transferred to Odessa in the same capacity. **M. L. Moore, Jr.,** of Gainesville, Texas, has become assistant district production foreman and transferred to Lovington, New Mexico.

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'Judge' Cloud, OU Professor, Honored by Oil Alumni

Christmas came early this year for Wilbur F. "Judge" Cloud, professor of petroleum engineering at The University of Oklahoma.

In appreciation for his 31 years of service and teaching at OU, students and alumni presented the professor of petroleum engineering with a $3700 check recently. He also received a plaque and a bound volume of letters of appreciation.

It happened at what started out as a routine meeting of the Petroleum Engineers' Club at OU. Then the alumni started drifting in, and the first thing you know Jack Abernathy of Oklahoma City was talking about what a fine man Cloud is and what he has done for students and the petroleum industry.

Abernathy, a former student of Cloud's, is vice president of the Big Chief Drilling Company of Oklahoma City and president of the American Association of Drilling Contractors.

Cloud was surprised and nearly speechless when he was handed the check for $3700 by John Perry of the Lane-Wells Company. The check represented contributions of students and former students now in the oil business. Perry said there'll be another installment, or check, when other members of the oil fraternity are heard from.

Cloud managed to thank everybody and gazed out at the faces of his friends in the engineering auditorium. A fine mist developed in his immediate vicinity which led to a constriction of the throat, and Cloud sat down by his wife.

"Judge" got his nickname by providing expert testimony before the state corporation commission. He was a student at OU when the school of petroleum engineering was first organized. The following year, 1925, he became a graduate assistant. Teaching has been his principal business ever since.

Cloud learned the oil business by serving his time as a rig builder, tool dresser, and safety engineer for the Marland Oil Company. Cloud also has done lease and consulting work. In 1937 he wrote a volume which became a widely used textbook, "Petroleum Production." The following year he was listed in "Who's Who in America."

During his 31 years as a professor of petroleum engineering, Cloud has seen hundreds of his students go to every major oil producing region in the world. He also has earned an international reputation.

His research has dealt with such various problems as porosity and permeability of oil sands, repressuring with air and gas, rate of flow and pressure drop while flowing saturated and unsaturated oils through sands, and underground pumping.

Cloud is a member of the American Association of Petroleum Geologists, the American Institute of Mining and Metallurgical Engineers, Sigma Xi research society, and Sigma Tau Beta Pi honorary engineering fraternities.

Cloud received his MS degree in 1926 at OU. He was principal of an elementary school at Mangum, Oklahoma, from 1914 through 1917 and was principal of high schools at Hobart and Paden, Oklahoma.

His plans for the future? Cloud intends to go right on teaching and learning more about getting oil out of the ground.

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made for your well!

No matter where your well is located . . . or how deep or shallow . . . there's a JENSEN JACK engineered to fit your pumping needs — exactly!

There are 13 different sizes and 24 different gear ratios. One man can change from single to double reduction, or from double to single, quickly — right in the field! Counter-balancing is also a quick, one-man operation. Write us or see your JENSEN Dealer.

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As a result, from Nova Scotia to Mexico, from Greece to Nevada, Magcobar construction supervisors, like this one, are working at plant expansions to assure a continued supply of high quality drilling fluids for the oil industry. These construction specialists are important members of the Magcobar team that provides the most complete drilling mud service in the oil fields.

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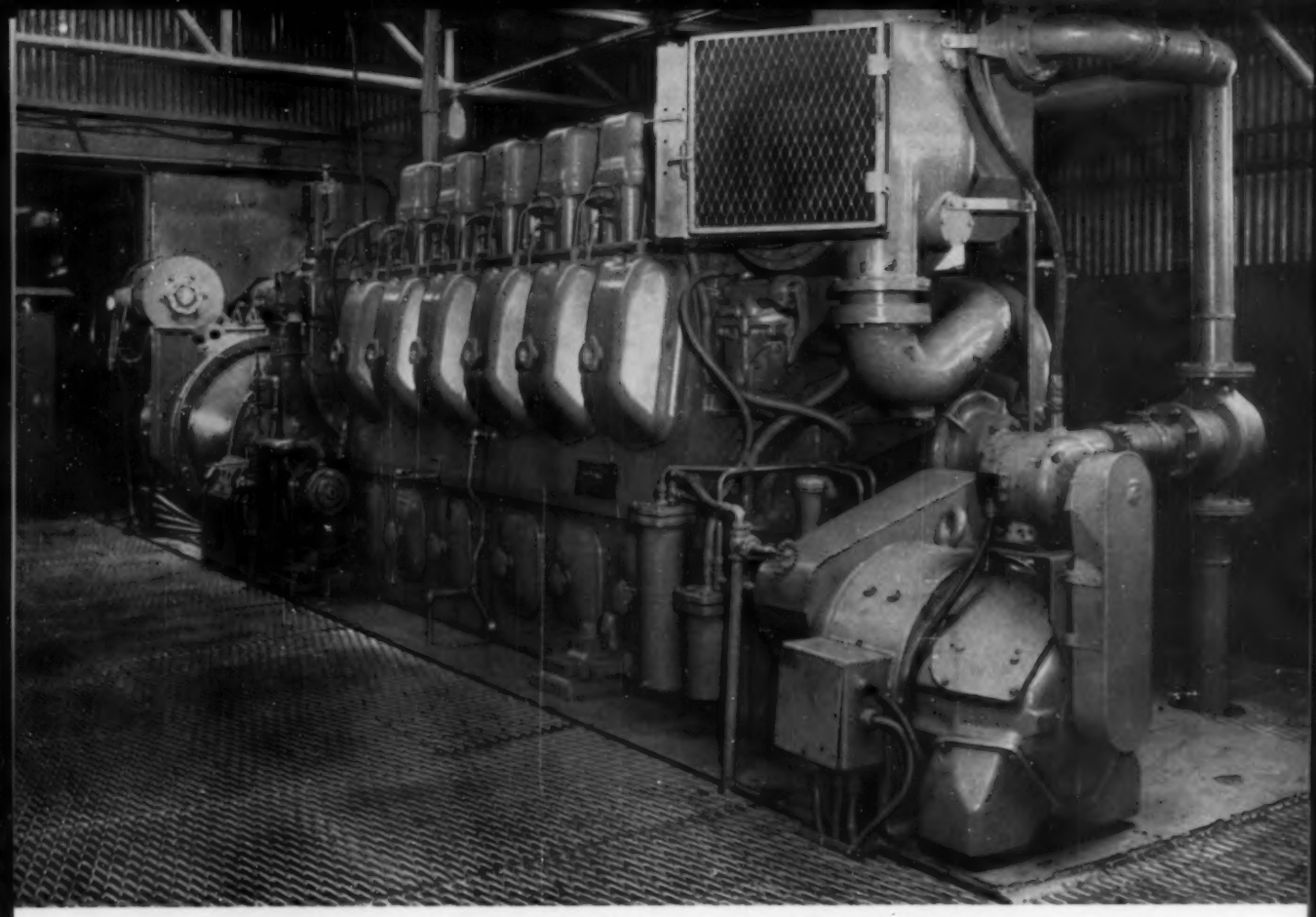

ALCO 251-B DIESEL ENGINE *in service on Shoreline Drilling Company oil-well drilling barge. Barge recently completed its second hole, which went 15,000 ft deep. First* ALCO *plant, owned by Bateman Drilling Co., has drilled over 80,000 ft. Offshore Company's first* ALCO*-powered rig has completed two holes. Drillers report excellent performance of* ALCO *equipment.*

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All components are skid-mounted. You distribute weight on a barge as required, save setup time on land installations. Components can be trucked from location to location.

Two engines in the ALCO plant provide 1370 hp for draw-works drive and 600 hp for each of two mud-pump drives, plus power for lighting and other auxiliaries. A wide variety of modifications is available, such as larger mud-pump, rotary and coring reel drives.

The ALCO plant's cost is comparable to that of an ordinary plant. It is built and backed by the pioneer of locomotives and diesel-electric power. Contact your nearest ALCO representative or write P. O. Box 1065, Schenectady 1, N. Y. for details.

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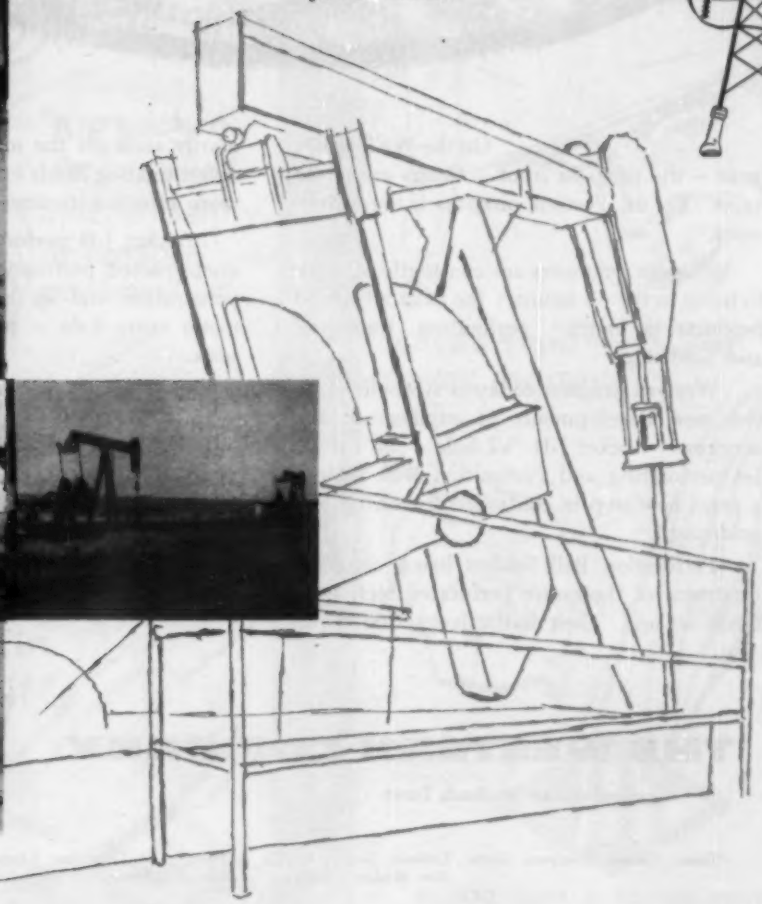

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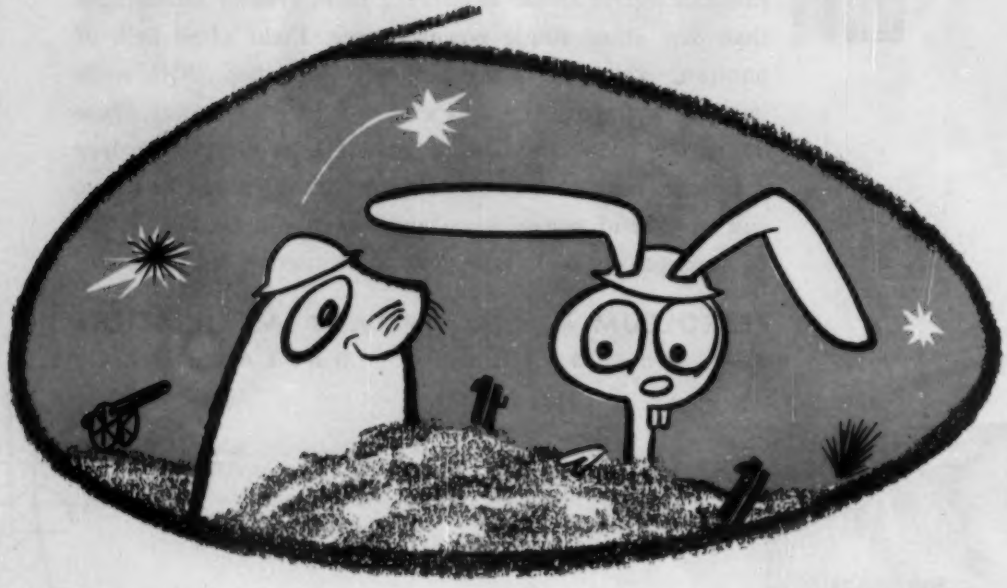
All ain't quiet on the Western Front!



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Western progress today is symbolized by two new developments in engineered well services – Rocket J-II "all hole – no carrot" Jet perforating and Perforation Ball Sealers, a great new step in controlled fracturing and acidizing.

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Rocket J-II perforating gives completely unobstructed perforations for more effective penetration and an amazing 5/8 inch diameter entry hole – proved by independent tests.

Rocket J-II and Perforation Ball Sealers are just two of the many examples of Western's engineered well service program. At Western, progress is an every-day fact – not just a word.

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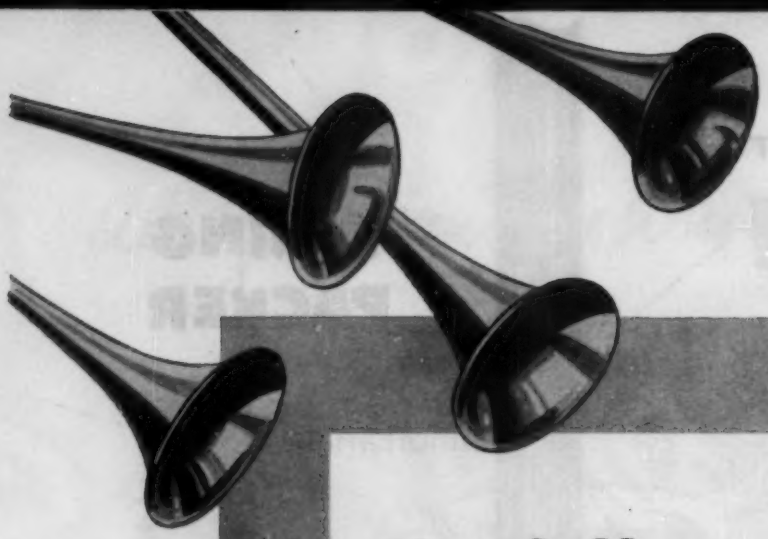

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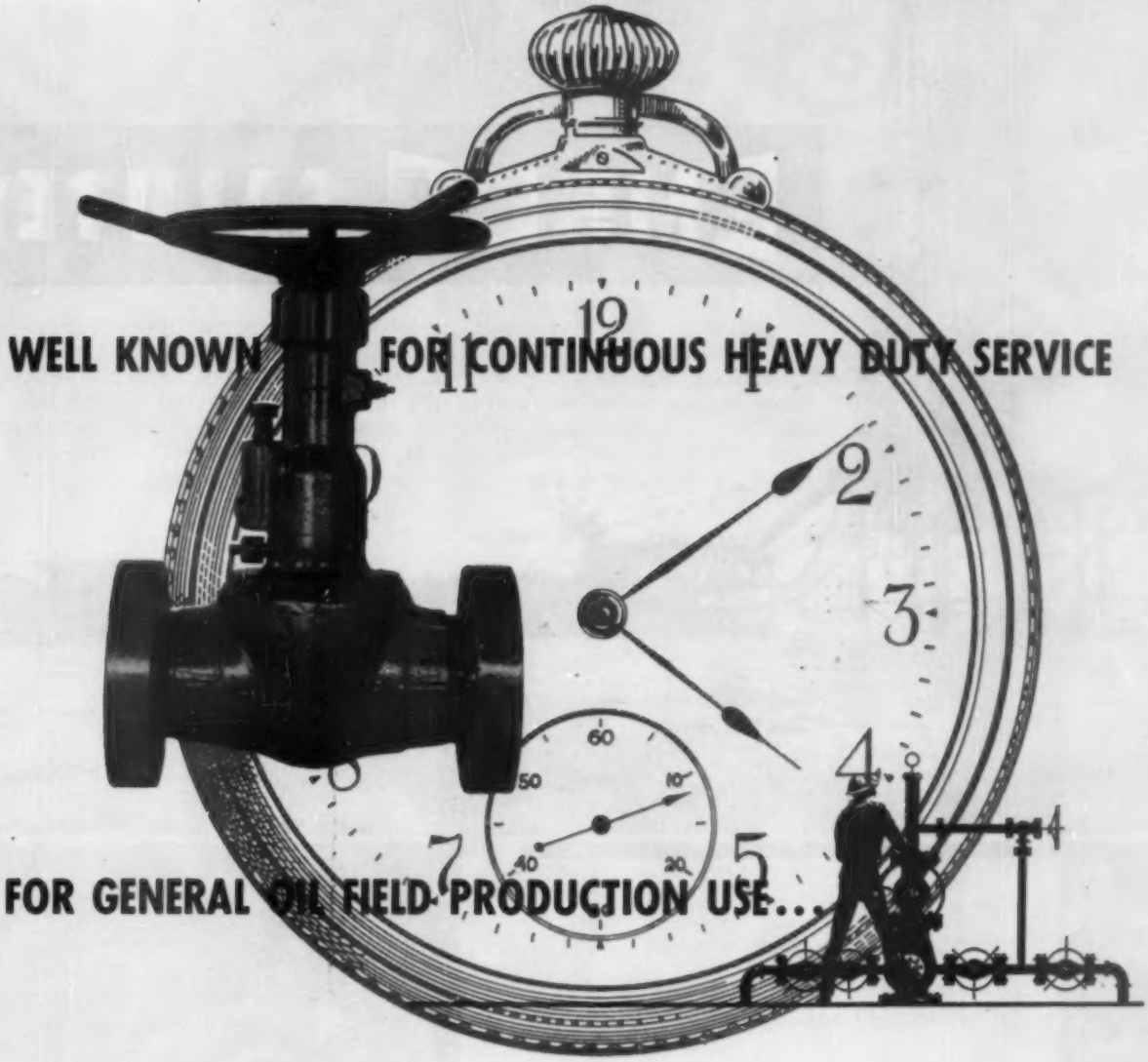

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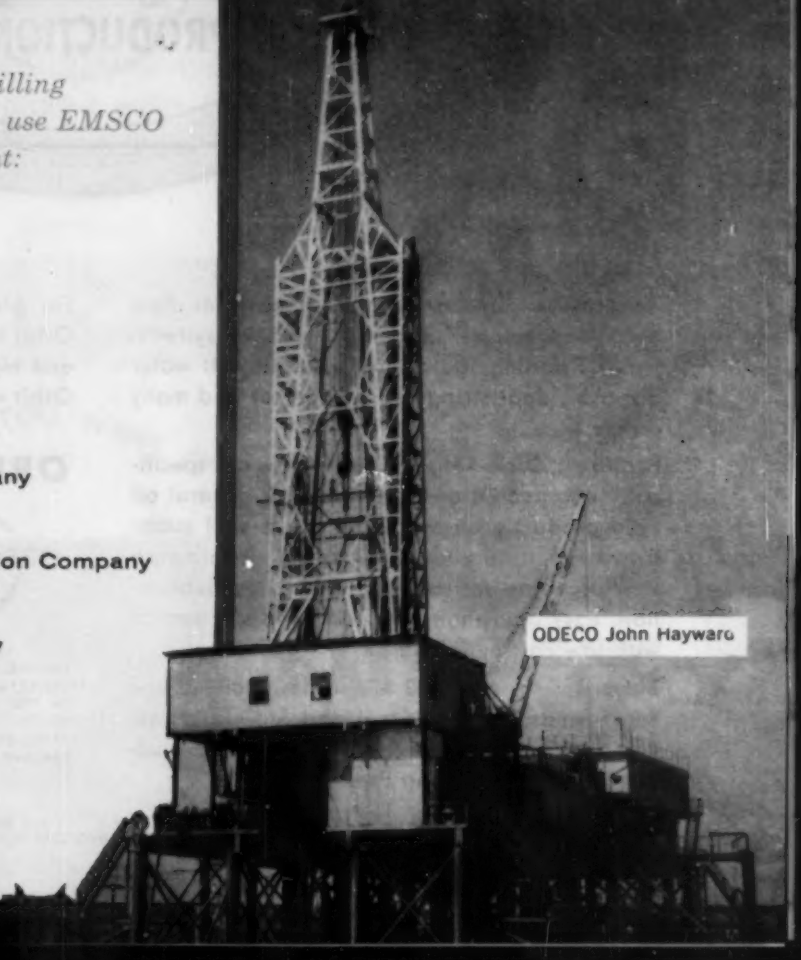
Phillips Petroleum Company
Wheless Drilling Company



OFFSHORE DRILLING

Offshore deep drilling is simplified through modern rugged Emsco drilling machinery. The Emsco all-electric "E" series rig is the very latest in a single package with integral motors according space-saving economy in a compact deep drilling rig. PJ 27½ cone roller bearing rotary table, L-400 heavy duty true cone roller bearing swivel, MA series crown and traveling blocks are all companion equipment capable of handling offshore deep drilling responsibilities twenty-four hours a day. Continuous uninterrupted service means an economical profitable well completion to both the operator and contractor.

Check these outstanding "E" Rig Features

1. Four Speed Drawworks 2. Built-in electric motor package 3. Totally enclosed pressure lubricated drives 4. 60" brake rims with total effective braking area of 2,640 square inches 5. Optional built-in Sandreel

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R-605

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proven a million times or more!

You would naturally expect the people who have had most experience with resilient seals to come up with the best practical solution to the mud valve problem. That is just what Cameron did, years ago.

Drawing on a vast backlog of experience with resilient seals for blowout preventers, master drilling valves, and wild well capping manifolds, Cameron engineers perfected the Flex-Seal Valve for mud lines. It was accepted immediately, and mud manifold maintenance the world over took a nose dive.

The reason? No other valve is quite as rugged. No other valve may be relied upon to operate freely and seal tightly after long and severe service. No other valve may be repaired at such low cost.

The Flex-Seal Mud Line Valve was not designed for obsolescence. Someday, if a better mud line valve is built, it will come from Cameron . . . specialist in producing equipment for the control of well pressures and drilling costs!

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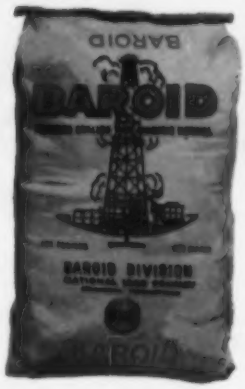

you buy one— you get FOUR

Only Baroid gives you so much for your mud dollar. Service begins with an engineered mud program before you drill.

During operations, Baroid's 24-hour service speeds drilling, prevents trouble, and saves you money.

Complete well reports are filed at Baroid Area Headquarters for planning your future mud programs.

Mud that costs you less is mud backed by the best service — Baroid service. Your total mud program works better, saves you money when you use Baroid all the way. Baroid area headquarters give you fast, complete, localized service. Your best mud buy is BAROID!

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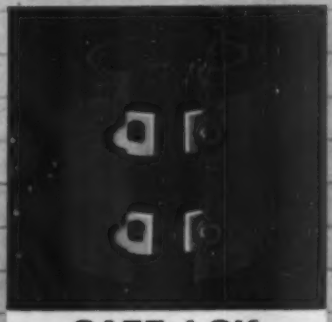
Here's how to combine Safe-Lok and Stretch-On Protectors for maximum protection at lowest overall cost!

Use Safe-Loks at top of string

Use "Stretch-Ons" below Safe-Loks to bottom of casing



SAFE•LOK

STRETCH•ON

PB PROTECTORS

Two different types of PB drill pipe and casing protectors are in use today. One is the popular PB "Stretch-On" which has been the favorite of the oil patch for years. The other is the relatively new PB Safe-Lok Protector which drilling crews can install or remove in seconds. These two protectors are natural partners in casing protection. Here's how this combination benefits you:

Safe-Loks are *time and money savers* at the top of your drilling string. Here their instantly removable and replaceable feature eliminates the laying down and picking up of rubbered pipe. You simply *remove* Safe-Loks (based on estimated bit footage) as pipe comes out of the hole, providing unrubbered pipe in the derrick for make-up behind your new bit.

You eliminate three time-wasting operations: (1) unnecessary transfer of rubbered pipe from derrick to pipe rack; (2) the handling of unrubbered singles from the rack for bit make-up; and (3) the return of rubbered pipe from the pipe rack for use within casing. Pipe is handled in *stand lengths in the derrick*. Safe-Loks are quickly replaced on unrubbered stands at the top of the string as you go back in the hole.

PB "Stretch-On" Protectors are used to provide protection on all pipe where protector removal and re-installation is not a factor.

Use this new money-saving PB protector combination on your longer strings. And use PB Safe-Loks exclusively on all shallow drilling.

Write for complete PB catalog...
including special clearance charts for selection of correct protector size.

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A full line of 47 models and types including small beam balanced units, beam and crank balanced models, or medium and larger types with the Alten screw-type adjustable counter balance. You can be sure of peak performance with every model in each series.

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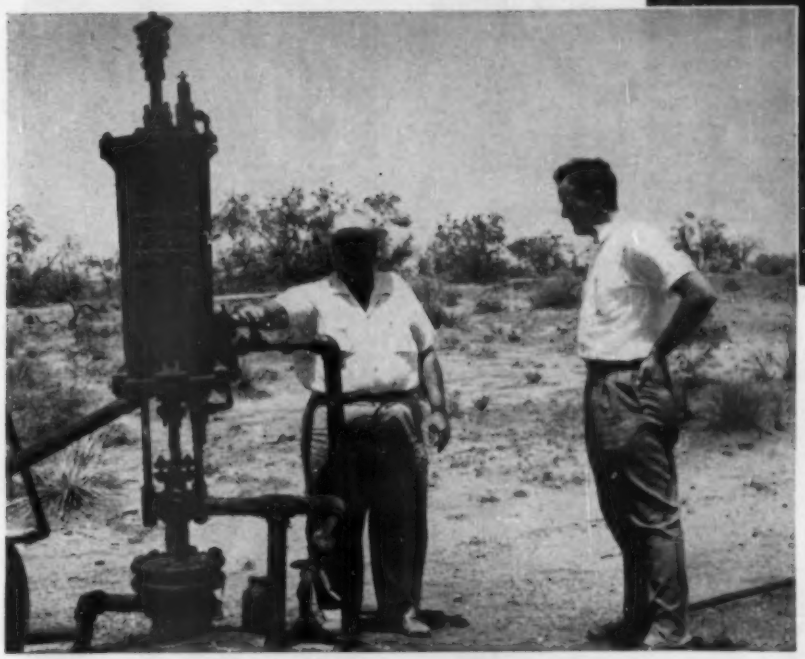
Foundry & Machine Works, Inc.
LANCASTER, OHIO

AXELSON PICTORIAL

WISE GUYS: This pair of baby horned owls was found by Windy Greene, Store Manager for Jones & Laughlin at Russell, Kansas, and Jimmy Drake, Axelson Representative, during a week-end fishing trip on the Saline River. The birds were in a tree nest wolfing down a large jack rabbit that the mother owl had caught for them. They made an Axelson working barrel their perch in the pump repair shop at Russell. Living on hamburgers and raw beef liver, a bird collector from Great Bend took pity and gave them a home. They are now twice this size; each bird weighs over 20 pounds.

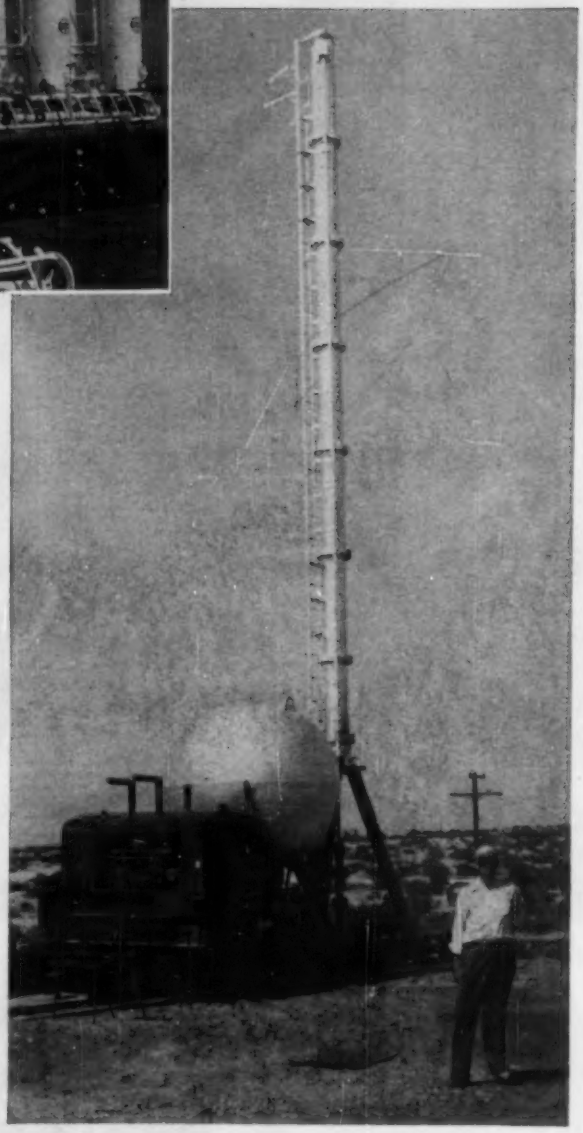


AIR LIFT. While drilling this well (McClure #1, Scurry County, Texas), a high-pressure gas pocket was hit at 1,200 ft. It was harnessed and used to actuate the sucker rod string through an "air-operated head." Air pressure is 200 psi, depth is 2,400 ft., production 4 B/D of 27 gravity oil. An Axelson 1½" bore Sure-Seal Pump has been in service for eight years without being pulled. L. M. "Woodrow" Wilson (l.) Production Superintendent for W. S. Guthrie Oil Company (producer) and Forest Goin, Axelson Representative, check pressure.

BUYERS' MARKET. Well known among oil men is Curt Oppel (center), Resident Purchasing Agent for the Atlantic Refining Company in their Dallas office. He is now in his thirtieth year with the Company. Flanked by his assistant, J. W. Crittenden (l.) and E. L. Chandler, Axelson Representative, Oppel has just signed an order for 40,000 feet of No. 60 Axelson Sucker Rods for East Texas wells.

AXELSON

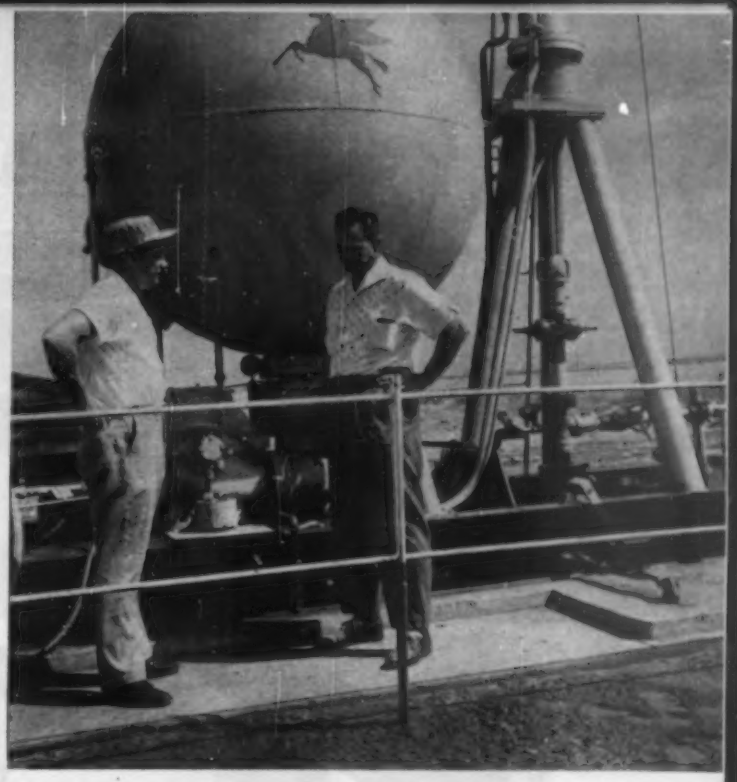
CARLOADINGS UP. These 10-foot counterbalanced units leaving the Axelson plant at Los Angeles are headed for the Dominion Oilfield Supply Company, Calgary, where they will be installed in Alberta's rugged Pembina Field. The newest addition to the line of Axelson hydraulic pumping units have an 18,000 lb. rod load capacity and can pump efficiently at eight strokes per minute.



DEFIES GRAVITY. About 30 miles south of Big Lake in Crockett County, Texas, this Axelson Long-Stroke Hydraulic Pumping unit raises sweet oil (39 gravity) from 6,200 ft. for Continental Oil Company. Five of the 40 producing wells in this water flood project (Todd-Crinodal) are equipped with Axelson Long-Strokers. Milton Barber, Project Engineer for Continental, in foreground.

6-FOOTER. Here on a stripper well near Kilgore, Texas, is a typical Hydrax hydraulic pumping unit. Jud Hemperly, Production Foreman for F. A. Fuller Company, checks the six-foot stroke length. He had an abrasive sand condition but the slow, smooth pumping cycle has reduced the fluid turbulence and ended this problem. This unit produces 32 gravity oil from a depth of 3,600 ft.

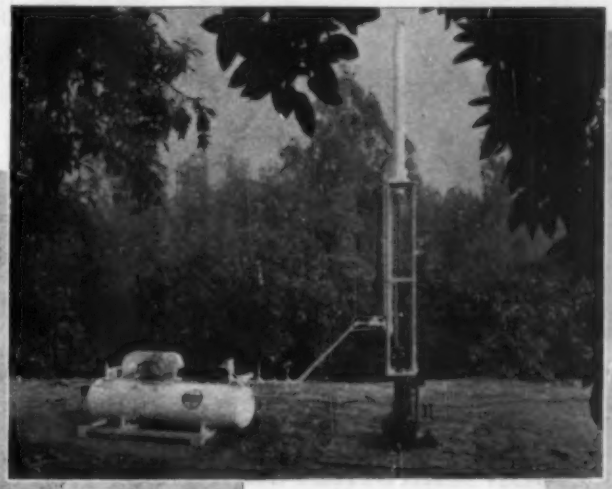
HYDRAULIC PUMPING. *On these two pages are illustrations of the four types of hydraulic pumping units that Axelson makes. They handle any producing depth from shallow, low-production pumpers to deep, high-volume wells. Stroke lengths range from four to 26½ feet. Some units are balanced, some are non-counter-balanced. Special units pump low viscous oil, multiple units pump from a single power source. Many are performing jobs economically that have never been done so before, without rod breaks and mechanical failures.*

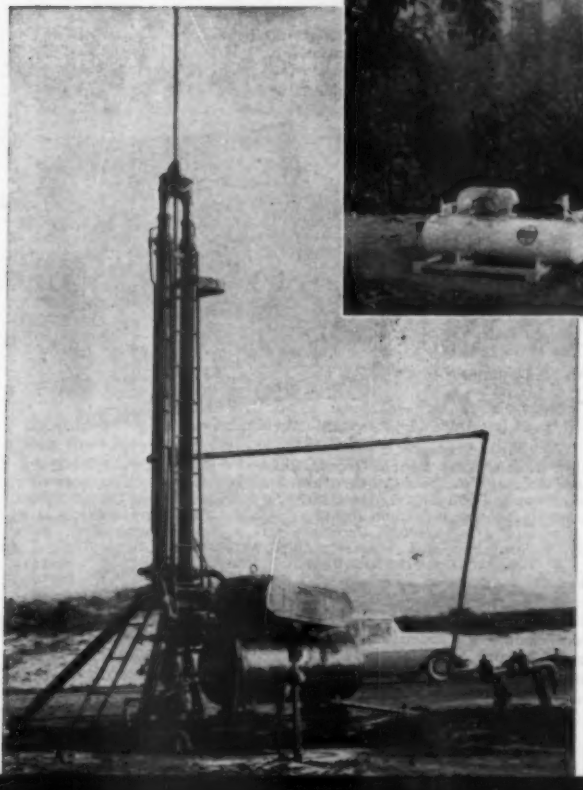


RIGSIDE. Magnolia Petroleum Company has 18 of these Axelson Long-Stroke Hydraulic Pumping Units on their Southeast Nolley Lease in Andrews County, Texas. In front of the E. E. Nolley #1 is Charles Hickok (l.) Magnolia Petroleum Engineer, and Roy Grigsby, Axelson Hydraulic Sales. This well makes its allowable of 157 B/D of 32 gravity oil from 9,400 ft. with an Axelson tapered rod string (⅞", ¾", ⅝").

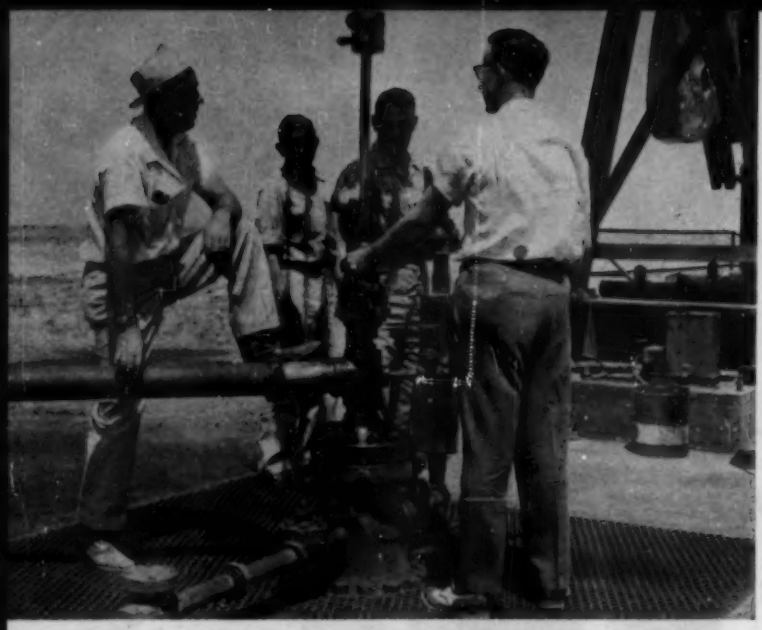
SMALL FRY. The four-foot Hydrax Jr. is a small, economical pumping jack for low-production and stripper wells. It mounts directly to the tubing nipple and requires no foundation. It can be installed within three hours. All controls are at ground level. Rod capacity is 8,000 lbs. First units were put on test, last Spring, and proved so successful that Axelson is now in full scale production with the Hydrax Jr.

AMAZON. Several hundred miles up the Amazon River, deep in the Brazilian jungles is the Novo Olinda Field. An Axelson Long-Stroke Unit is being installed on the first producing well in the region for Petrobras (Petroleo Brasiliero). The unit now pumps 425 B/D from 8,900 feet with an Axelson 1½ bore insert pump and an Axelson three-step sucker rod string.





NOTORIOUS. Called the "Double Ram," this unit was specially designed for Union Oil Company. There are 18 of these "Hydrax" units in the Guadalupe Field, California, pumping eight to 14 gravity oil from a depth of 2,800 to 3,100 ft. Pumping conditions here are notoriously rough. Sand cuts run as high as 50%. This unit operates at one stroke per minute (35 sec. on the upstroke, 25 sec. downstroke), lifting 65 B/D with an Axelson 2½" pump.



AXELSON PICTORIAL

HOT ONE. This is Amerada Petroleum Corporation's Mathers A#2, East Cap Rock Field, Lea County, New Mexico. An Axelson 2¾" bore TLE Pump lifts 1,350 B/D (75 bbls. net of 45 gravity oil). Total depth is 11,030 ft.; pump is set at 3,573 ft. Bottom hole temperature of 180° F. does not affect the pump. (l. to r.) Buck Cummings, Farm Boss; Carl West, Pumper; Gene Thomas, Resident Engineer (all of Amerada); Truman Coffee, Axelson Representative.

RETIRING. W. A. Underwood (right), Production Foreman for Cosden Petroleum for 13 years, retired on June 30, 1956, after 50 years of service in the oil fields. He poses for his picture beside the Patterson #1, Howard County, Texas, with Bernard Layman, Jones & Laughlin Field Representative. Axelson Sucker Rods and Plunger Pump are going strong in this well. Depth is 3,100 ft. Production is 100 B/D of 31 gravity crude oil.

NO. 7

AXELSON

AXELSON MANUFACTURING COMPANY

Division of U. S. Industries, Inc.

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Specify **AXELSON** *for*
Subsurface Pumps
Sucker Rods
Hydraulic Pumping Units
Stuffing Boxes & Packing
for better production

Where to buy Axelson Production Equipment:

CALIFORNIA: *Axelson stores at Bakersfield, Coalinga, Huntington Beach, Long Beach, Orcutt, Santa Fe Springs, Taft, Ventura; Hickey Pipe & Supply Co. (Sucker Rods)* • **MID-CONTINENT:** *Jones & Laughlin Steel Corporation, Supply Division (Headquarters, Tulsa)* **ROCKY MOUNTAINS:** *Jones & Laughlin Steel Corporation, Supply Division; Great Northern Tool & Supply Co., Billings, Montana* • **CANADA:** *Jones & Laughlin Steel Sales Co. Ltd., Calgary; Dominion Oilfield Supply Co. Ltd., Calgary* • **MEXICO, D. F.:** *Wells Fargo & Co. Express, S. A.* • **RIO DE JANEIRO, BRAZIL:** *MAQUIP (Commercial de Maquinas e Equipamentos) S. A.* • **LIMA PERU:** *Gross Equipment, S. A.* • **LA PAZ, BOLIVIA:** *Del Prado & Compania, Ltd.* • **BUENOS AIRES, ARGENTINA:** *Adrian Bolland & Cia., S. R. L.* • **BARCELONA, VENEZUELA:** *Servicios Industriales, C. A.* • **MARACAIBO, VENEZUELA:** *Servicios Industriales, C. A.* • **BOGATA, COLOMBIA:** *Servicios Industriales, C. A.* • **TRINIDAD, B. W. I.:** *Industrial Agencies, Ltd.*

Where to buy Axelson Hydraulic Pumping Units:

CALIFORNIA: *Axelson stores (see above)* • **ODESSA:** *Axelson Warehouse* • *Industrial Supply Company stores at* **DALLAS, ELECTRA, FORT WORTH, FREER, HOUSTON, KAMAY, MIDLAND, ODESSA, SAN ANTONIO, SNYDER, TULSA, TURNERTOWN, WICHITA FALLS** • *Mountain Iron & Supply Company stores and offices at* **ANTHONY, AUGUSTA, BARTLESVILLE, DENVER, GREAT BEND, INDEPENDENCE, KIMBALL, LEROY, MADISON, McPHERSON, PARKERSBURG, PLAINSVILLE, RUSSELL, TULSA, WICHITA** • *Export (See above).*

NEW Drilling and Producing Equipment

(1) Portable pH Recorder for Field Surveys. Portable, self-contained, pH measuring and recording instruments requiring

no external power supply are available from Bristol.

Device consists of two units: a Bristol Model 524 pH recorder and a Beckman N-2 amplifier. This equipment will cover the total pH range of 0-14 in two partial ranges of 0-8 and 6-14. Selection is by means of a switch located on the amplifier. The two units together weigh less than 50 lb, and are compactly arranged for easy transport from one location to another.

The Bristol Company.

(2) Air-Cooled Engine. Another model Wisconsin Air-Cooled Engine has been announced by Wisconsin Motor. It is designated as "Model VH4" — a 30-hp, 4-cyl V-type engine designed to fill the gap which has existed between the 25-hp Model VF4 and the 36-hp Model VG4D.

Wisconsin Motor Corporation.

(3) Drilling Table for Shallow Depths. First of a new line of National rotary machines has been announced by National Supply. Type SA-175 rotary machine in the 17½-in. size with 44-in. API spacing

of sprocket from table center has replaced the FE-17½-44 for shallow and medium-depth drilling.

Several improvements have been made. First is the rectangular shape of the machine, including the removable top guard. This simplifies installation in the derrick substructure and permits rig flooring to be fitted up flush with the table top on all four sides for safer working areas.

The National Supply Company.

(4) Gasoline Injection. Development of a gasoline fuel injection system for internal combustion engines has been announced by Borg-Warner.

Fuel injectors, which may eventually replace the conventional carburetor on cars, trucks, and tractors, are currently commanding special attention throughout the automobile industry.

In an engine equipped with fuel injection, precisely metered amounts of fuel are sprayed directly into the air in the intake manifold at a point just before it enters the cylinder. Air for the air-fuel mixture is brought to this point separately and does not mix with the fuel until the two meet at the combustion chamber opening.

Borg-Warner Corporation.

(5) Air Drilling Compressor. A semi-portable, skid-mounted, "package" compressor unit specially designed for air drilling has been announced by Joy Manufacturing.

Unit, the Joy AP-2, is a completely self-contained compressor plant, with two heavy-duty, stationary-type compressors, powered by either diesel or natural gas engines. Output is rated at 1056 cfm for 125 psig and 647 cfm for 250 psig. Mounted on a single heavy-duty, oil-field type skid, the unit is entirely within road limits for highway transportation at any time.

Joy Manufacturing Company.

(6) Soft-Seat Metering Valve. Made from stainless steel barstock, and incorporating a replaceable plastic seat made from nylon, a valve specifically designed to give exceptionally long trouble-free, bubble-tight reseating action has been introduced. The plastic seat withstands metering action and unless severely damaged will continue to give leak-proof shutoff action, the manufacturer says.

Straight-through, high-volume passages and the non-lubricated rising stem design eliminate flow directed against stem seat and threads. With the valve installed in the line, and system pressure off, the stem, seat, and bonnet can be replaced without breaking the system connections.

Anderson, Greenwood & Co.

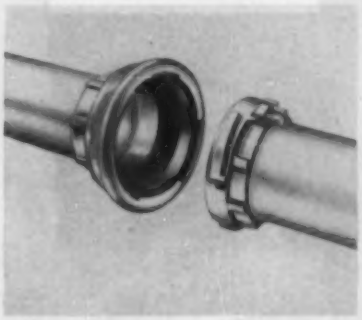
(7) Improved Mud for Shale Conditions. A mud which is said to improve drilling fluid performance in troublesome shale formations is now offered by Magnet Cove Barium.

Called T-8 Mud, it offers many advantages in addition to hole stabilization and inhibited shale hydration.

This mud can be used wherever lime mud is currently employed and is exceptionally effective for penetration of the troublesome shale zones. The mud is prepared using T-8 Compound as the conversion and primary maintenance chemical and creates a mud system that is in a state of "controlled dispersion" when operated within the proper chemical limits.

Magnet Cove Barium Corporation.

(8) Coupler for Lightweight Portable Pipe Lines. What is said to be the first industrial coupler for portable aluminum pipe lines that will withstand working



pressures up to 1000 psi, available both in OD and IPS pipe sizes, has been developed by the John Bean Division of Food Machinery and Chemical.

Advantages claimed for the FMC Fast Move Coupler included: Fastest-acting coupler designed; heavy breach-acting jaws secure the coupler with a quarter turn; a lock screw spins up in an instant and locks the coupler against untwisting through line torque, and no metal part of the coupler is exposed to the material within the line.

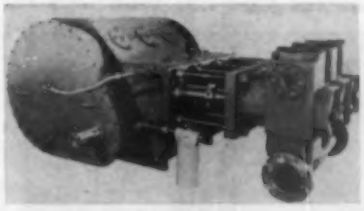
John Bean Division, Food Machinery and Chemical Corporation.

(9) Bottom-Hole Sampler. A Coleman sampler for obtaining true samples of fluids in well bores is operated from the surface and is claimed to give positive indication of depth at which sample is taken.

Unit has a minimum number of parts and no complicated mechanism to fail. Constructed throughout of stainless steel, it is 1½ in. in diameter and 67 in. long, with a capacity of one liter. Sample pressure can be determined at the wellhead without opening the sampler.

Coleman Instrument Company.

(10) High-Pressure Pump. Twentieth Century Manufacturing and Supply has announced its Series 5000 Triplex plunger



pump for working pressures up to 10,000 psi.

Some of the pump's specifications include: Plunger sizes to 6½ in.; working pressures to 10,000 psi; maximum net horsepower is 750; maximum strokes per minute are 210; maximum plunger loading to 200,000 lb; overall dimensions are 55 in. x 38 in. x 93 in.; approximate weight 10,500 lb.

Twentieth Century Manufacturing and Supply Company.

Tips on Mud Valves for Toolpushers . .

Zack Taylor (right) and Toolpusher Jim Wilkson discuss the MUDWONDER on the standpipe of the Falcon-Seaboard Rig No. 9.

Mud Valve Economy, Easy Operation Found In Rockwell-Built MUDWONDER

by Zack Taylor, Division Manager
Falcon-Seaboard Drilling Company, Denver, Colorado

ECONOMY . . . Easy operation . . . Have you searched in vain for mud valves that would give you these benefits? We did until our experience with Rockwell-Built *Mudwonders*. Now, we use them on standpipes, mudlines, mud tanks, blowout preventers, etc. Eight months of testing and using *Mudwonders* proved to us that they are superior to any mud valve we have ever used, regardless of application.

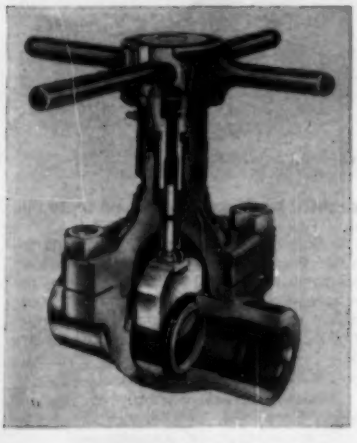
Economy means more to us than just long wearing parts which are inexpensive to replace. It means freedom from downtime and costly maintenance, too. *Mudwonder* valves give us "our type" of economy. We can inspect the inside of a *Mudwonder*, change the seat insert if necessary, and be ready for operation again while the crew makes a connection.

We never need a cheater or hammer on a *Mudwonder* valve. Easy operation is no longer a roughneck's dream. It's real . . . and at extreme differential pressures, too.

We can recommend *Mudwonder* to any toolpusher having mud valve trouble. *Mudwonder* valves are built in 2", 3", and 4" sizes with screwed or flanged ends for 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test).

See your favorite oil field supply store for complete information, or write Edward Valves, Inc., East Chicago, Indiana.

MUDWONDER cut-away view shows the double thread construction, separated stainless stem and hard chromed gate with "T" slot connection and the one-piece seat insert with the buna-N molded integrally over the steel wear rings.



ADVERTISEMENT

B-158

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(22) Equipment and Services. Perforating Guns Atlas has announced completion of its entirely new catalog. Topics covered by the enlarged edition of PGAC's catalog, all fully illustrated and explained in detail, include all services performed by the company.

Some of the well perforating subjects discussed are: Penetration problems, acidizing, comparative costs, fracturing problems, casing-size problems, well temperature problems, combination bullet and jet perforating, evalution of perforating equipment, etc.

Perforating Guns Atlas Corporation.

(23) Wire Line Services. Great Lake Petroleum Services has available a new "fortune-size" 16-page color brochure describing in detail its wire line services.

Included is a brief history of GLPS, and completely illustrated sections on the company's advanced equipment and services—the 7/16-in. line perforating truck, the 3/16-in. line through-tubing perforating truck and accessory equipment, gamma ray-neutron logging instrumentation, gun perforators, jet perforators, and other wire line services.

Great Lakes Petroleum Services, Inc.

(24) Friction Materials. *Industrial Friction Materials* is the subject of an illustrated, 16-page booklet issued by Johns-Manville. It covers asbestos brake blocks, linings, and clutch facings.

Booklet opens with descriptive sections on moulded asbestos friction materials, woven materials, and assembled sets for servicing popular industrial machines. Then there is a large section on design data, with most of the information arranged in chart form for easy reference.

Johns-Manville.

(25) Reciprocating Pumps. A new data sheet which contains complete information on Aldrich 25-hp to 2400-hp direct-flow pumps is available from Aldrich Pump.

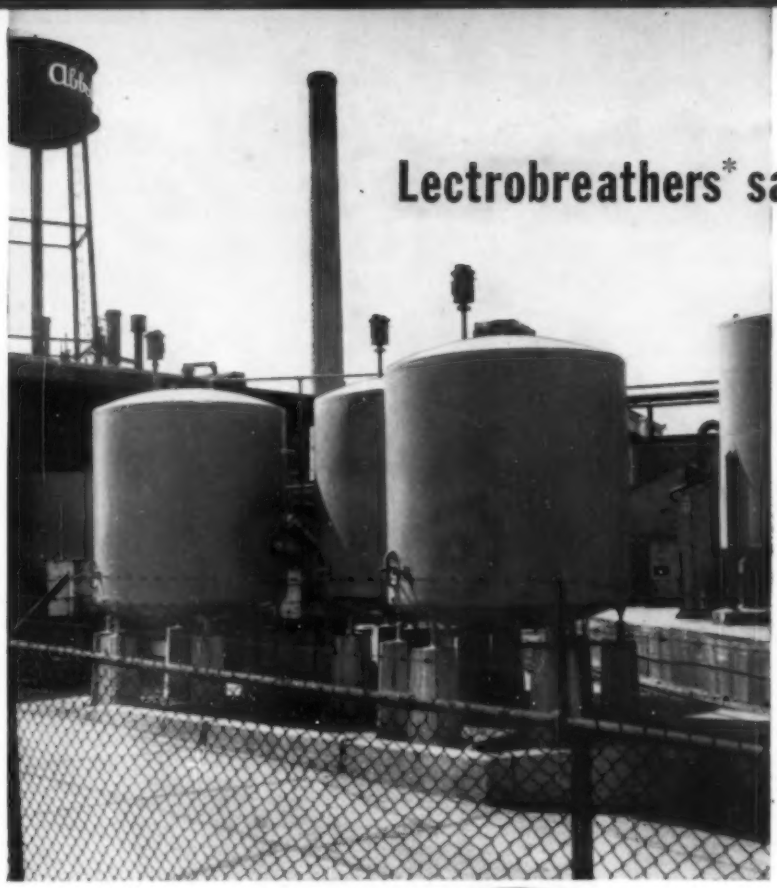
It describes and illustrates the Aldrich-Groff "Power-Savr" pump's stepless, straight-line control of capacity — from zero to rated output without any change in speed of power source. In addition to design and material specifications, this condensed catalog also presents dimension tables and a pump selection chart for the complete Aldrich line.

The Aldrich Pump Company.

(26) Pumping Units. Crank counter-balanced pumping units having an API beam load rating of 24,000 lb and peak torque of 228,000 in.-lb are presented in a new bulletin by National Supply.

This 8-page bulletin covers design, construction, and specifications of the National Type E-24, largest of a line of six basic Type E units, and one of 12 basic sizes of National pumping units with 18 standard specifications in beam and crank counter-balanced types.

The National Supply Company.



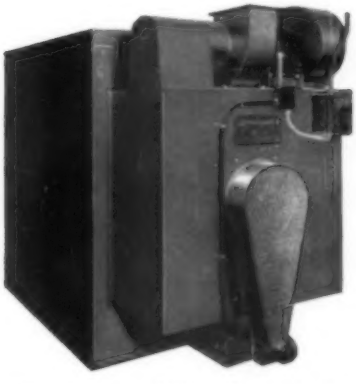
You see Lectrobreathers extending above tanks and rooftops at the Abbott Laboratories plant in North Chicago, Illinois.

Lectrobreathers* safeguard chemicals in storage—permitting carload purchases

● Buying liquids in tank car lots saves money. But profits are quickly washed out if storage tanks are allowed to inhale wet air as they breathe, contaminating their contents.

Abbott Laboratories solved this problem by installing Lectrobreathers on many of their outdoor and indoor storage tanks. Now, as pressures vary and those tanks draw in outside air, that air is DRY. The original high quality of their contents is preserved.

Lectrobreathers and Lectrodryers make certain that any tank, little or big, breathes only DRY air. For help in selecting the equipment you need, write Pittsburgh Lectrodryer Company, 334 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).



Where volumes of air are large, as in a tank farm, a Lectrodryer serves as a breather. Its DRYing-reactivation cycle is continual, so it stays right on the job.*

◀ *A tank breathes freely as air passes through the Activated Alumina adsorbent and is dried DRY. When a Lectrobreather needs reactivation, it is lifted off and a spare takes its place.*

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
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LECTRODRYERS DRY
WITH ACTIVATED ALUMINAS

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...the new FOXBORO M/44 INDICATING PRESSURE TRANSMITTER

- **Easier to Read . . . large indicator scale, visible at 20 ft.**
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Any way you look at it, the new Foxboro M/44 Pneumatic Pressure Transmitter gives you an unmatched combination of fine engineering and economy. First; because it *is* an engineered instrument. There are no attachments or "makeshifts". Second; because it utilizes standard Foxboro parts throughout—parts which have been performance-proved in thousands of successful installations of other Foxboro Instruments. And this means not only top performance, but easier servicing and stocking as well. Third; calibration is simple, right in the field, because the M/44 is "convenience-designed" by men with years of experience in every phase of instrument design and application.

In appearance, too, the M/44 has unmistakable Foxboro quality. Features like the high-legibility indicator scale, the compact drawn-steel case with tough polyester plastic cover. It's the neat, high-efficiency, low-cost pressure transmitter for centralized operation or control. All standard ranges.

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INSTRUMENTATION FOR INDUSTRY

With some hard-hitting examples, the author shows how engineers can profit by attacking problems in a logical, orderly manner

Practical Economics for Refinery Mechanical Engineers

Thad S. Fennema
Engineering Specialist,
Humble Oil & Refining Company,
Baytown, Texas

This article is based on the premise that once a problem is clearly defined, the alternative methods of solution should be enumerated and investigated, then the most practical and economic alternative should be selected as the solution. Any other alternative which is used, above the base case, should be justified on an established payout basis. Several typical examples are presented as evidence that it is necessary to think, inquire, investigate, evaluate, and *act*.

EVERY day in every way every "Don Dunn" (the engineer) is being bombarded with ideas and special formulas to use in becoming (a) "imaginative" (b) "creative," and (c) "cost conscious." This is good. Some of the reasons for presentation of this type of material are to get all the "Don Dunns" to think, inquire, investigate, plan, evaluate and act. The work is planned, then the plan is worked.

"So what," says Don Dunn, the experienced engineer or the engineer who recently received his diploma, "We use all or a combination of these techniques in our business." Do we really, Don? — How about considering a few questions, such as:

1 Do engineers take time to think — or are we denied time since we usually have a large back-log of work?

2 Do we determine if a problem has one basic solution?

3 Do engineers study a problem which has several solutions, define and evaluate the alternates, then recommend the most practical and economical solution?

4 Are some of us the stereotyped engineer, who through engineering experiences and mature judgment on our part "know what things will work, where to look up needed knowledge, and methods to apply to reach acceptable solutions to stated problems (1)?[1]

5 Are engineers prone to evaluate on the basis of past experience?

6 Doesn't good judgment come from experimenting?

All right, Don, (he's that other engineer), let's assume that most problems, in any field of endeavor, can be solved practically and economically by applying some very basis principles, such as (2):

1 *What is the problem?*

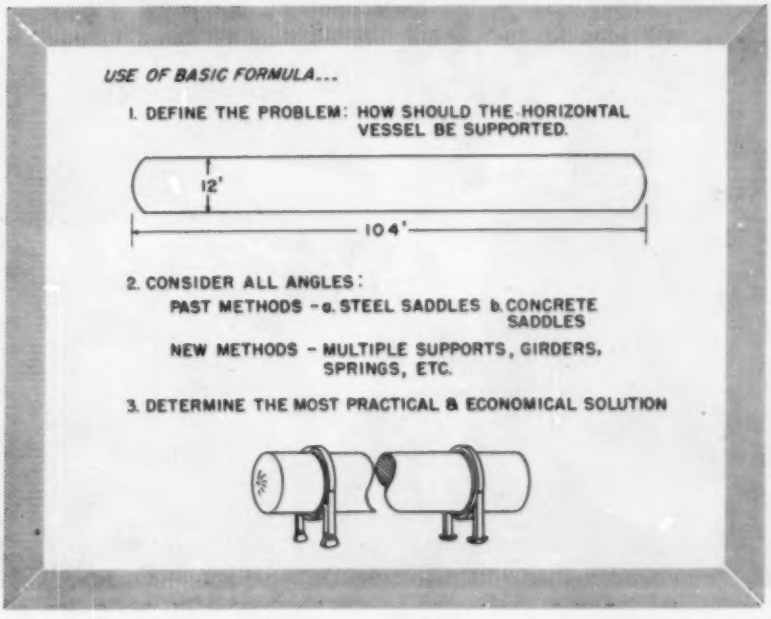
(a) Define its scope, objectives, and limitations, if any.

2 *How many ways can this problem be solved?*

(a) What are the alternates, economic considerations, etc.?

3 *What is the most practical and economical solution?*

(a) If a higher cost alternate is


USE OF BASIC FORMULA...
1. DEFINE THE PROBLEM: HOW SHOULD THE HORIZONTAL VESSEL BE SUPPORTED.
12'
104'
2. CONSIDER ALL ANGLES:
PAST METHODS - a. STEEL SADDLES b. CONCRETE SADDLES
NEW METHODS - MULTIPLE SUPPORTS, GIRDERS, SPRINGS, ETC.
3. DETERMINE THE MOST PRACTICAL & ECONOMICAL SOLUTION

[1] Presented at the ASME Petroleum Mechanical Engineering Conference, Dallas, Texas, September 23-26, 1956.

Tracing the path of fuel with carbon-14

Ethyl Research tags 1 in 100,000,000 atoms with radioactive carbon for a better picture of distribution in the cylinders.

by D. E. COOPER

Ethyl Corporation, Detroit, Mich.

The distribution of fuel components and fuel additives to the cylinders of multicylinder engines is of prime importance to the petroleum industry. Just as a chain is only as strong as its weakest link, so is an engine's performance limited by the one cylinder which does not continuously get its proper dosage of high-octane hydrocarbons or of tetraethyllead.

The goal of engine designers is the creation of an engine wherein the fuel/air ratio, hydrocarbon composition and additive concentrations are identical for each cylinder of a multicylinder engine. Fuel injection—now becoming commercially available—represents one approach to the solution of this difficult problem.

Whether fuel injection or carburetion is employed, however, an accurate knowledge of fuel and additive distribution in engines is necessary to assure optimum use of the gasolines the refiner is producing today.

A continuing study

As is the case with most of Ethyl's other basic research studies, the study of fuel distribution has been a continuing one. Some years ago, a glass manifold was installed on an engine and motion pictures were made of flow patterns, giving some insight into the quantities of fuel mixture fed to various cylinders.

A second step in Ethyl fuel distribution studies involved the tagging of specific hydrocarbons with deuterium or heavy hydrogen. One component (the cyclopentanes, for example) had a specific number of hydrogen atoms replaced with heavy hydrogen. This special fuel was then burned in the engine. Samples of the exhaust gases from various cylinders were condensed and analyzed in a mass spectrometer to give a picture of the distribution of that particular

FIGURE 1. Nose view of combined sampling valve and spark plug.

FIGURE 2. Test engine in the laboratory and gas sampling and collecting system.

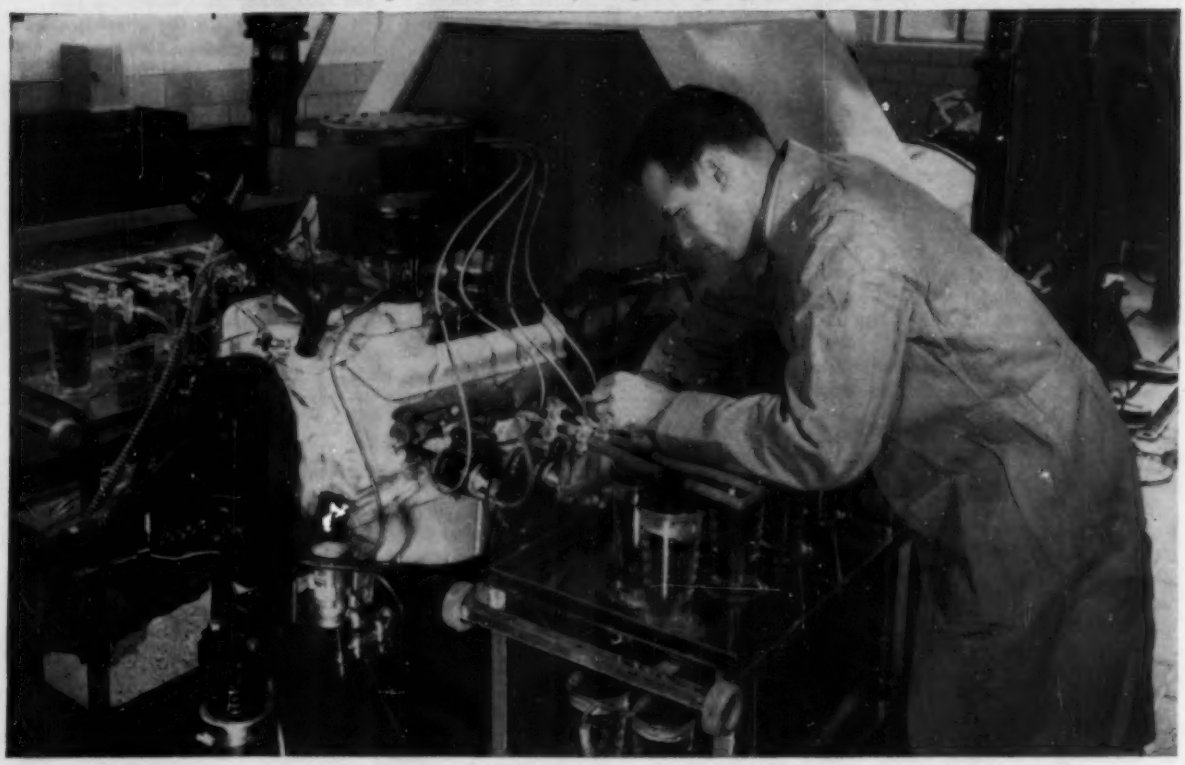


FIGURE 3. Scintillation counter setup at Ethyl Research Laboratories for examining tritium-containing condensate samples.

hydrocarbon among the cylinders of the engine on test. This technique required, however, that the ratio of heavy hydrogen to normal hydrogen be at least 1 to 100 and thus ruled out studies of additive concentrations, which are much smaller.

Tagged carbon atoms

A third step in this continuing program of fuel distribution studies has involved switching from a stable isotope such as deuterium to a radioactive one such as carbon-14. Now it becomes possible to tag tetraethyllead with carbon-14 and measure its concentration in an engine cylinder accurately, even though only one tagged atom is present among 100,000,000 normal carbon-12 atoms!

All of these distribution studies involved the use of a quick-opening (1/1,000 second) sampling valve. This valve samples the contents of a particular cylinder. It is screwed into the spark-plug opening and combines the sampling valve with spark-plug electrodes. Figure 1 shows a nose view of this combined sampling valve and spark plug.

Figure 2 shows the test engine in the laboratory and the gas sampling and collecting system. The gas samples are bubbled through absorbing solutions of barium hydroxide. The carbon dioxide is regenerated and transferred to an ionization chamber, where its beta activity is measured by a vibrating-reed electrometer.

And now . . . tritium

The newest refinement in this study consists of the replacement of carbon-14 with hydrogen-3 or tritium as the radioactive tracer element. The use of tritium simplifies and makes less expensive the preparation of tagged hydrocarbon or additive molecules for study. It also simplifies the exhaust-gas-sample collection technique. The scintillation counter used for studying the tritium-containing condensate samples from the cylinders is shown in Figure 3.

As is the case with all of our basic research studies, the information from this continuing study of fuel distribution is available to the petroleum industry. We would be happy to discuss any particular aspect of this problem with you in your office. We would also be happy to have you visit our Detroit Laboratories to see this equipment and discuss it with our technical personnel. In either case, contact your local Ethyl representative for an appointment.

What Ethyl Research offers you

Ethyl Research is in the unique position of serving both the petroleum and automotive industries.

In that capacity, we have contributed much in the field of fundamental as well as applied research. Today at our laboratories in Detroit we are conducting studies on the distribution of fuel components and fuel additives to the cylinders of multicylinder engines.

Searching for answers to these basic problems has led us to develop many new instruments and new techniques. The information which we have developed from our research efforts is being constantly circulated throughout both the automotive and petroleum industries to help them with their research.

If you desire any information concerning fuel-engine problems, just contact your Ethyl representative.

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(Advertisement)

selected, it should be justified on pay-out, policy, etc.

Most every design problem has some real or assumed criteria, or a combination of the two. Design criteria which immediately come to mind are such things as:

1 Is there an established method? (Engineering, code requirements, limitations, etc.)

2 Does this conform to accepted policy?

3 If this is a replacement — how about replacing in kind and in place?

4 Does experience indicate that this problem can be solved in the same manner as a previous problem?

These are some thoughts that may come to mind on most any problem. Let's look at some examples and see where extra thought and investigation has resulted in attractive payouts.

The first example shows how the most economical solution did not conform to past standard practices.

Problem

Design adequate supports for a horizontal vessel 12 ft ID by 104 ft tangent to tangent. Operating pressure 10 psig, safety-valve setting 65 psig, operating temperature 45F, temperature range 30 to 120F. Due to soil conditions it is assumed that differential settlement will be a maximum of 2 in. during the life of the vessel.

Usual Methods of Support

1 Steel saddles.

2 Concrete saddles.

Possible Solutions

There were many methods considered such as multiple supports, girder supports, and even some such as to support the vessel on a bed of sand, float on water springs, etc. Why not employ a consultant who has had experience with similar problems? Maybe the forest is not visible for the trees or experience limits ability due to judgment factor.

Selected Solution

A consultant (3) was engaged and a novel design was completed in a few days. The vessel was supported in the following manner:

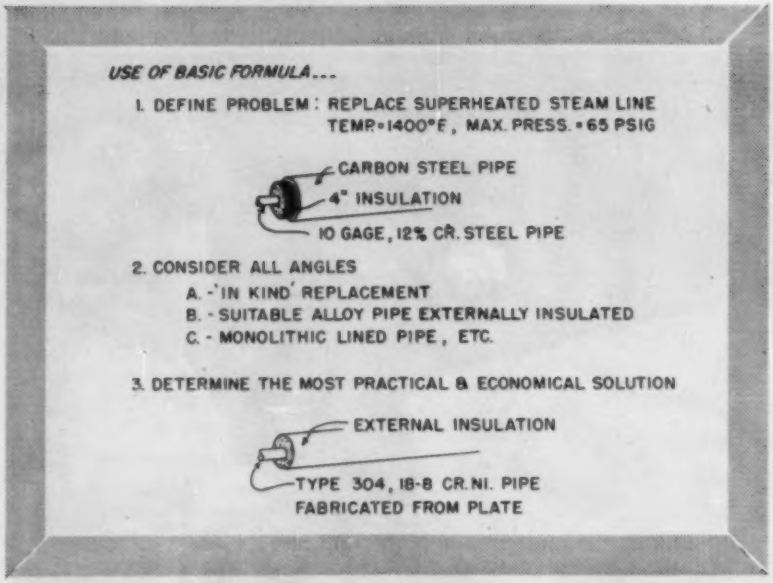
1 Each of two ring-girder stiffeners was located about 18 ft from the heads of the vessel.

2 The two supports were columns welded to the stiffener rings.

(a) There were two columns at each support, welded to the stiffener ring at the horizontal center line of the vessel.

1 One set of supports was equipped with welded-on beveled shoes.

2 The other set of supports was equipped with beveled rockers attached to the columns with pins.


USE OF BASIC FORMULA...
1. DEFINE PROBLEM: REPLACE SUPERHEATED STEAM LINE
TEMP.=1400°F, MAX. PRESS.=65 PSIG
CARBON STEEL PIPE
4" INSULATION
10 GAGE, 12% CR. STEEL PIPE
2. CONSIDER ALL ANGLES
A. - 'IN KIND' REPLACEMENT
B. - SUITABLE ALLOY PIPE EXTERNALLY INSULATED
C. - MONOLITHIC LINED PIPE, ETC.
3. DETERMINE THE MOST PRACTICAL & ECONOMICAL SOLUTION
EXTERNAL INSULATION
TYPE 304, 18-8 CR.NI. PIPE
FABRICATED FROM PLATE

Advantages of Selected Solution

1 With the vessel supported at only two places the problem of differential expansion and settlement was minimized.

2 The rocker and bevel supports allowed expansion and settlement to occur and still maintain allowable stresses in the relatively thin walled vessel.

3 A conservative estimated saving of $2000 was realized in using this design.

This brief description of a mechanical design problem shows that the most economical solution was selected and in this case the most economical solution did not conform to standard past practices.

Problem

Replace superheated steam piping at a process unit. Temperature of steam 1400F. Operating pressure 65 psig (safety-valve setting). Present piping consists of a 10-gage, 12 per cent Cr stainless-steel pipe sleeve inside a carbon-steel pipe. Assembly of the two pipes is such that a 4-in. annular ring is formed. Insulation is packed in this annular ring.

Some Possible Solutions

1 Replace "in kind."

2 Replace with suitable alloy-steel pipe externally insulated.

3 Replace with pipe fabricated from suitable alloy-steel plate and insulate externally.

4 Replace with monolithic-lined pipe.

Selected Solution

The most suitable and economical replacement proved to be externally insulated pipe fabricated from Type 304, 18-8 Cr Ni plate.

Economics of Selected Solution

1 Maintenance costs reduced.

2 Process debits caused by piping failures reduced.

3 Increased safety over "in kind" replacement.

4 Savings in installation costs by:

(a) Elimination of flanges no longer needed for inspection and repairs.

(b) Use of pipe fabricated from plate to obtain exact wall thickness needed for service. Plate-thickness tolerance=0.01 in. under nominal thickness. Seamless-pipe tolerance = 12.5 per cent under nominal wall thickness.

A saving of approximately $35,000 was realized in installation costs by the design engineer because the problem was thoroughly investigated. The most economical solution was determined and selected which deviated greatly from past procedures and practices.

Problem

Install a piping system in a process unit. The conditions stipulated were:

Contained media — hydrocarbon vapor (approximately 90 per cent H_2.

Pressure	285 psig
Temperature . . .	1100 F

Original Solution

The materials plannned for use in the piping system were designed for the stipulated conditions. This system required considerable piping and a sizable investment.

Investigation

Prior to fabrication a refinery mechanical engineer investigated the design requirements which disclosed the following:

1 Processing conditions had been set up for entire installation on the

basis of the most severe conditions at a given point. The design pressures actually varied from 160 to 265 psig.

2 The design temperature had been padded; i.e., it was higher than the maximum expected temperature. Actual design metal temperatures for piping varied from 550-50-1065F.

Alternate Solution Selected

The proposed system was broken down into a number of systems based on using revised design conditions (maximum operating temperature and pressure for each system).

Economics of Alternate Solution

1 The new system was equally as safe and operable.

2 Savings were made on investment.

3 Structural provisions were reduced.

4 Flexibility problems were reduced.

This example is presented to show that it pays to be inquisitive and to investigate. Each "Don Dunn" should be alert to determine if the information presented is correct and how the design can be changed to effect economies of installation as well as of maintenance.

Problem

Replace atmospheric cooling tower.

Possible Solutions

1 Replace "in kind."

2 Use present basin — install tower to span basin.

3 Use spare capacity of tower serving another unit in the vicinity.

4 Install a manufacturer's standard tower and basin.

5 Install a manufacturer's standard tower on a sloping slab and use present basin.

Selected Solution

A manufacturer's standard tower which met design conditions was installed on a sloping slab. A flume was run from the slab to the present basin. The new tower was placed in service and the process unit was kept on-the-line. Process credits were appreciable because the unit did not have to be shut down for tie-in. This is another case where Don Dunn, the mechanical engineer, used his head for thinking, investigating, evaluating and recommending an economical solution.

Have you ever heard an engineer say, "This is such a small, insignificant job, let's use an established procedure." Maybe with a few minutes, or more, of intense creative thought, sandwiched in between larger jobs, a better way could be thought of to do the job. If it isn't thought of now, someone else will develop a better way to do it later. Why not take a little extra time and use the basic formula of: (a) What is the problem; (b) what are the possible solutions, and (c) which is the best solution? Let's look at some examples of jobs where a little extra thought saved some money.

The Author

Graduating from Oklahoma A & M in 1938 with a BS in civil engineering, Thad S. Fennema joined the engineering division at Humble's Baytown Refinery in 1940 after two years of dam building in northeastern Oklahoma. During his 16 years with Humble, he has been doing mechanical engineering design work, spent some time on training assignments in other departments, and participated in Humble's Executive Development Program. He now holds an engineering specialist's rating in the engineering division.

Problem

What is the best way to clean an exchanger bundle that is completely coked (the bundle is fabricated on a square pitch to facilitate cleaning)?

Possible Solutions

1 Sandblast.

2 Chemical or solvent clean.

3 All other known methods were considered.

4 An idea is born—"Say, why not use a gasoline-powered chain saw—and saw coke from cleaning lanes?"

Solution

The use of the chain saw proved effective in removing the hard coke deposit, and the field engineer who developed the idea has made refinements to the saw in order to minimize damage to the tubes. The set of the teeth was eliminated and the gasoline engine was replaced with a variable-speed electric motor. Final cleaning is by sandblasting. The tube bundle can be cleaned faster and put back in service. By thinking, the engineer developed another use for a chain saw and one which pays off for the user.

Problem

Provide handling facilities for a tube bundle.

Possible Solutions

1 Provide monorail.

2 Use temporary rigging facilities each time.

3 Wait a minute—the piping in this unit is being revised to take care of additional capacity — the exchanger faces into the unit—why not turn the exchanger around and use mobile crane for pulling and handling bundle when required?

Solution Selected

The solution selected is obvious, isn't it?

Economics

Since the piping had to be revised—the exchanger could be rotated 180 deg horizontally at a cost less than $100. The tube bundle could then be removed by a mobile crane and placed directly on transportation equipment. This eliminated the problem of removing the bundle by more laborious means in a congested area.

Problem

About 500 bicycles are used in a refinery for transportation and messenger service. They are left out of doors at all times in a high-humidity atmosphere where the annual rainfall averages 50 in. Yearly dismantling and repainting is required.

Possible Approaches

1 Continue to paint annually.

2 Quit painting bicycles.

3 Why not hot-dip-galvanize the bicycles the next time dismantling and painting is required?

Solution and Economics

It proved economical to hot-dip-galvanize bicycles which in turn;

1 Cost less for galvanizing than repainting.

2 Eliminated all painting for the life of the bicycles.

3 Minimized downtime, maintenance costs, and parts replacement.

Problem

A new furnace is being built—what accessories are required on the self-supporting stack?

Standard Past Requirements

1 Provide trolley rail complete with trolley and handline (to be used by steeplejacks and/or painters).

2 Provide ladder (inside or outside—optional).

3 Provide manway near bottom for cleaning and access.

Accessories Actually Required

A few inquiries proved that field and/or contract personnel never trust, nor will they use, the trolley, the trolley rail, or the ladder after the stack has been in service. If they don't use the accessories, why provide them? Small savings, but still a savings. The usual practice (standard design requirements) had been used for quite some time as the "things the field need." Our friend Don Dunn, the mechanical engineer, might say, "If a job has been done the same way for 20 years there is bound to be a better way to do it." The stack was purchased with only one accessory—the manway for access and cleaning.

Problem

Don Dunn, the design engineer, has a backlog of capital improvement projects. Everyone is after Don to finish his job first.

Possible Approaches

1 Work on the ones where the operators of the equipment (or others) scream the loudest. (The squeaking wheel policy.)

2 Work on the project that has the most attractive return on investment.

3 Work on the project which has been approved the longest.

4 Work on the project which it is thought (but not known) management is interested in.

5 Develop a priority system for approval.

Selected Solution

Prority and scheduling system which was approved for use by all personnel concerned:

$$\frac{\text{Annual return on investment}}{\text{Construction mandays to complete job}} \times \frac{1 + \text{months since job was approved}}{12}$$

The only person who can change the priority is a designated representative of top management.

Along with priority shouldn't Don Dunn, the engineer, also develop a schedule of the manhours of engineering time required for each project? Of course, there must be flexibility to take care of those ever-present, ever-demanding "hot jobs" that just must be done.

A design engineer, in order to do his job correctly, must co-operate and co-ordinate his efforts with that of other staff and line organization personnel. He must step into the problem at precisely the-right time so the problem will be solved with a minimum of overlap of holdup.

Problem

What is the proper time for a mechanical engineer to go to work on the design of a new process unit, or proposed revisions to existing equipment?

Possible Solutions

Old Don Dunn, the mechanical engineer, could:

1 Wait until the project is approved by management,

2 Or start a little earlier when the project is in the hands of the project engineer (estimator),

3 Or, get in near the inception of the project and do "pre-engineering" (develop the mechanical design).

Selected Solution

Let's assume a refinery where process, project (estimators, project managers) and design engineering are handled by different personnel. When should the design engineer "get into the act?" Shouldn't he be in on the ground floor even though actual design work may not start at this stage—the background knowledge would be worth a lot in making decisions later. Don Dunn might ask, "What if the project is cancelled, hasn't a lot of manpower been wasted so far as the design engineer is concerned?" Could Don have been doing more productive work? Sure, if it was known that the project would be cancelled, otherwise, no. The design engineer should be in on the job at its inception so he can participate in the planning and investigation and thereby be able intelligently to come up with economical solutions during the course of the job.

If the "consumer" has his own engineering staff, then the vital force of "competition for the job" is not the natural factor forcing improvement that drives "contracting firms" to find more economical ways to do a job. Staff groups, unless some means of competition is generated internally, can become insulated from outside competition and grow complacent. J. E. Arnold (1) has some very good points in his paper, "The Creative Engineer." He says, "Our society dictates that we must be practical and economical above all things, and as a result, judgment comes into play too quickly. It is not polite to be too inquisitive, or too wise to doubt everything. We have a tendency to put too much faith in statistics or in reason and logic. There is a growing tendency to have all or nothing, and certainly indulging in fantasy is a waste of time, or a pastime for fools."

Maybe all of us aren't the hypothetical Don Dunn, graduate engineer, but here are some questions that Don can ask himself as he tries to apply practical economics to his everyday business decisions:

1 Do engineers, those who have had years of experience as well as the young engineers who are recent graduates, really look for a better way to do every job?

2 Are we set in our ways and do we usually select the easiest way out?

3 Are we prone to judge on the basis of our experience?

4 Do we tend to add too many "engineering-ignorance-factors" so we will be 150 per cent sure that it will work?

5 Is our engineering staff alert for all possible ways of economizing, consistent with good design practice?

6 Are we critical of young engineers who have "bright-ideas" or do we just condone the "bright-ideas" and say to ourselves that we were young and foolish once?

7 Do we criticize and judge before we hear the facts, i.e., do we have the attitude which says, "My mind is made up—don't confuse me with the facts?"

8 Do we strive to encourage engineers to think?

9 Are we able to sell our ideas effectively?

10 Do we give up when we are struck out in the first inning or do we come back for each inning of the game and try to get a hit (sell the idea)? It takes a good salesman to sell a new idea.

11 Can you think of anything which can't be improved? Improvements can always be improved, can't they?

12 Doesn't a creative mind see problems and seek solutions?

13 Can't the following basic formula be used in solving engineering problems?

(a) Define the problem.
(b) How many possible solutions can be established?
(c) What is the economical solution?

Acknowledgment

The author gratefully acknowledges his indebtedness to all of his associates and the management of the Humble Oil & Refining Company, without whose co-operation this work could not have been done.

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★ ★ ★

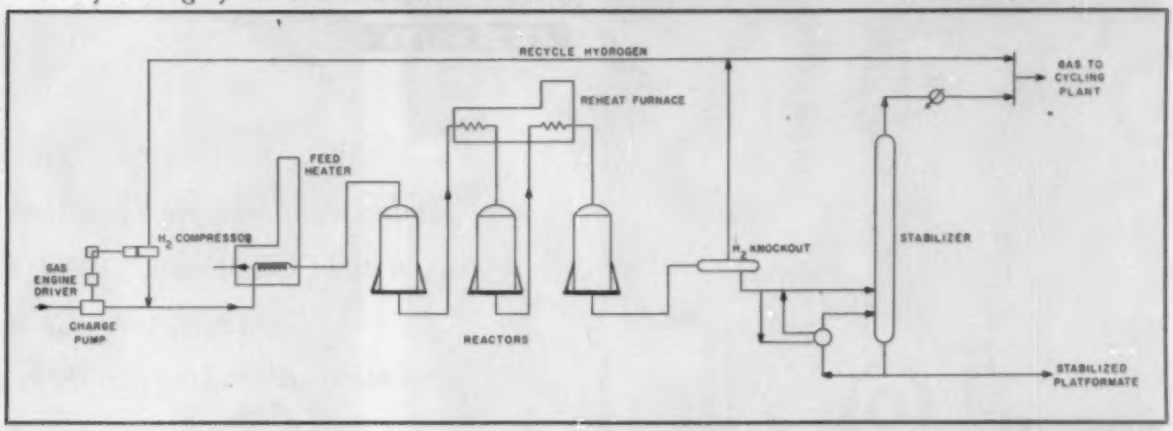
Fluor Second-Place Award For Its Annual Report

The Fluor Corporation, Ltd., has been awarded national recognition by *Financial World* magazine for the excellence of its 1955 annual report, placing second in the construction service industry classification of the 16th annual survey conducted by the New York publication.

Fluor placed second behind Merritt-Chapman & Scott, New York. Morrison-Knudsen Company, Inc., Boise, Idaho, won a third-place award.

The Los Angeles, California, engineering, construction, and manufacturing concern also received a special merit award for "distinguished achievement in annual reporting for nine consecutive years."

Five thousand annual reports for 1955 and early 1956 were reviewed and rated in 100 industrial classifications. The three best reports in each category were selected by a committee of 20 security analysts.



EXCLUSIVE

Midget Cat Reformer Upgrades Light Natural Gasoline

WITH a 700 BPD Platformer as its only major installation, the South Hampton Company is operating one of the country's smallest, uncomplicated refineries. The unit, which went on stream in July, receives light natural gasoline feedstock from the adjoining South Hampton cycling plant, located near Silsbee, Hardin County, Texas. Most of the Platformate is piped to the Silsbee cycling plant, about four miles to the east, where it is sold as a high octane gasoline blending component.

The South Hampton cycling plant is jointly owned by several companies and is operated by Sinclair Oil and Gas Company. Also operated by Sinclair, the Silsbee cycling plant is owned by a different group than that owning the South Hampton cycling plant. In the middle of this complex corporate structure is the South Hampton Company, organized and owned by John C. Breaker, a Houston independent. Breaker founded his company specifically for the purpose of building and operating the catalytic reforming unit.

Breaker, formerly vice president of Gasoline Plant Construction Corporation, engineered and built the unit from data provided by Universal Oil Products Company, licensor of the Platforming Process.

The South Hampton unit, along with four other catalytic reformers operating in conjunction with natural gasoline and cycling plants, seem to be forerunners of a trend towards production of high octane finished gasolines from natural gasoline plants. This will relieve the dependence which natural gasoline producers have had upon refiners of crude petroleum for a product outlet.

While several natural gasoline plants purchase additional feedstock for their catalytic reforming units, the South Hampton plant is the first that is adjacent to a cycling plant that is not owned and operated by the operators of the cycling plant.

It's a unique unit . . . designed for virtually unattended operations, a complex alarm system in the control house and in two nearby houses alert the plant's personnel in the event of emergency or upset. A portable gas engine powers both the feed pump and the recycle hydrogen compressor, assuring "fail safe." With separate drivers, complex instrumentation would have been required to assure that, with failure of either the compressor or the feed pump that the other would shut down immediately. Loss of recycle hydrogen would cause the catalyst to coke rapidly, while loss of feed would cause considerable damage to occur in the furnace tubes and other heat transfer surfaces.

There are several automatic shutdown points in the plant. Normally ordinary high or low level "alarm" in more conventional units, they include:

High stack temperature in both heaters.

High or low recycle gas flow.

High level in compressor suction scrubber.

High temperature to product separator (to protect against cooling water failure).

Alarm points which are connected to the operators' houses include:

High or low level in product separator.

Low instrument air pressure.

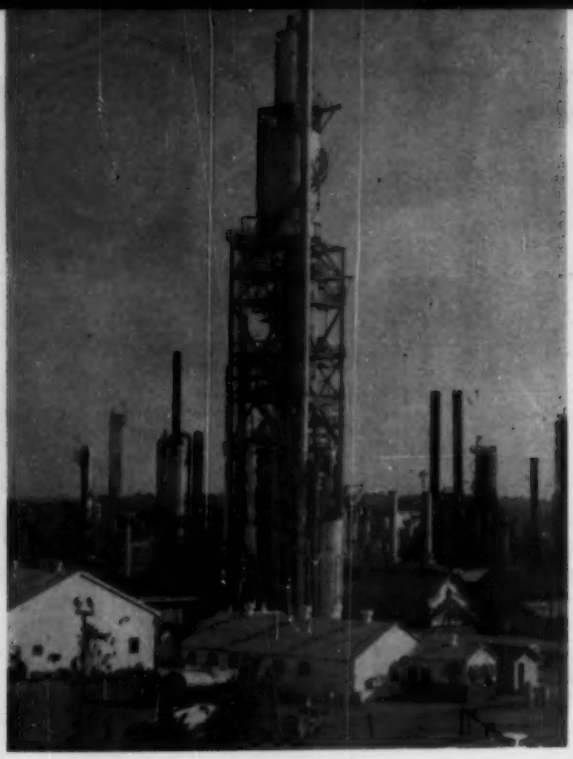
Low recycle gas flow, that would sound in the event of any plant shutdown device operation.

The feedstock, which is piped over from the South Hampton cycling plant, is a debutanized light neutral gasoline, boiling in the 110 to 400F range. It has relatively few naphthenes and aromatics, contains only 0.002 wt per cent sulfur.

The Platformer is usually operated to produce 86 CFRR-clear, 97 CFRR leaded (3 cc TEL) motor gasoline blending component. The plant is capable, however, of producing octanes far in excess of this level. Although the feed is relatively light and has high paraffin content, yields are from 88 to 90 per cent on feed, depending on severity of the reforming operation. The stabilized product has a relatively low mid-boiling point. Consequently, it is very suitable for "front end" fill on today's high octane premium gasolines.

Operations are virtually integral with the adjoining cycling plant. There are no feed storage tanks; Breaker's Platformer receives feedstock directly, also fuel gas for the recycle compressor-feed pump driver. Net hydrogen production is mixed with the stabilizer overhead and returned to the cycling plant. ★ ★ ★

EXCLUSIVE

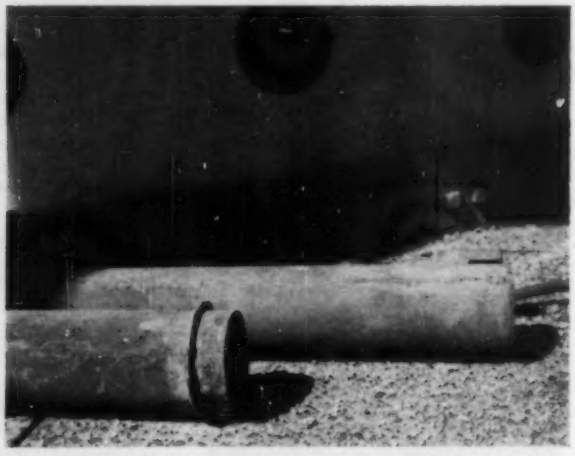


American Liberty's Airlift TCC Unit — Mt. Pleasant, Texas, Refinery.

Pre-Planning Cuts Downtime For Unscheduled Turnaround

With but three days notice, Amlico made complete turnaround on its TCC unit in only 12 days. Progressive preparation and materials stocking was the key

WHEN mechanical failure was encountered in the kiln section of American Liberty Oil Company's Thermofor catalytic cracker, decision was made to initiate a complete turnaround at that time. The regular turnaround had been scheduled for two months later. Twelve days after shutdown, the unit was onstream. This was a record, four days shorter than the downtime required on previous major turnarounds. This feat was



The unexpected shutdown resulted from a weld failure in this catalyst pipe in the kiln.

Chunks of fused catalyst and pieces of metal and refractory were found in 48 of the 144 catalyst collector pipes in the bottom of the kiln.

The carbon steel catalyst lift pipe was badly eroded from the 36 ft to the 72 ft levels. Shown is a section which had eroded through and had been patched with ⅝-in. plate.

A six-foot section of the new dual metal alloy lift pipe being positioned. Sections were clip-bolted and welded on the outside. Machined faces assure a smooth internal fit.

accomplished even though Amlico's mechanical forces had received only three days notice to prepare for the overhaul. The company's program of pre-planning and materials stocking for the unexpected paid off!

Savings resulting from this preparation were enormous. To continue operations would have required a severe cutback in feed rate on the 5100 BPSD (rated) catalytic cracking unit and result in a tight supply situation. The record-breaking turnaround has made it possible to fulfill committments that otherwise may have not been met had they limped along until the scheduled time for the turnaround.

Within 24 hours of notification on the impending shutdown, complete work lists had been distributed to process and mechanical foremen. Metal tags were placed on all lines to be blanked, their return indicating that the instructions had been carried out. Likewise, each assigned job was given a number and a metal tag attached near the site of the work. Return of this tag to the mechanical office indicated completion of the job. The foreman and superintendents thus had an "at a glance" report on the progress of work.

Also, before the actual shutdown, cutting torches, welding machines, portable air compressors, and other heavy equipment and tools were moved in and spotted. Repair materials, especially the large items, were likewise placed in positions easily accessible to the job site.

Upon receipt of the job list, each mechanical foreman estimated the man-hours required to complete each assigned job. On this basis, 100 men were placed in groups, headed by a foreman, which were responsible for individual areas or sections of the 255-ft catalytic cracker and its feed preparation and product fractionation sections.

Actual repair work was limited to only 12 hours a day. Clean-up crews worked at night, clearing debris, removing and replacing insulation as required, and making preparations for the morrow's work. Working conditions were therefore excellent, both speeding the work and maintaining Amlico's safety program during the hurried overhaul activities. There were no lost-time accidents during the turnaround.

The amount of work done in 12 days was staggering. The task group of 100 men, in addition to tearing apart and making needed repairs to the cracking, regeneration, and after processing equipment, replaced a total of 68 ft of the catalyst lift pipe, and a huge elbow in the top kiln flue gas outlet was shop-fabricated and installed.

Replacing sections of the 24-in. diameter, 225 ft high catalyst air lift pipe was the biggest single job done during the turnaround. Not only were the sections from the 36 to the 72 ft levels badly eroded, but the top 32 ft of the low-alloy steel lift pipe was found to be near failure. Twenty-four feet of hard-faced pipe were on hand to replace the top section and fabricators were able to supply the additional eight-foot section in time to avoid delay.

It is American Liberty's policy to assess not only realized trouble spots during runs on its units, but also to anticipate potential causes of failure or breakdown. A list of these items is examined periodically by the refinery's engineering staff to determine probable repair materials requirements. Although certain items may not be needed for a year or more, orders are placed immediately. Because of this practice, nearly all of the materials required were on hand at the time of the unscheduled shutdown.

For example, erosion in sections of the catalyst lift pipe had been observed during a turnaround in September, 1955. While it was expected that this carbon steel section, which extended from the 36 to the 72 ft levels, would last for another year, no chances were taken. Orders were placed immediately for pipe made from a material more resistant to erosion. The dual-metal pipe that was installed is centrifugally cast with a high carbon-chrome alloy used on the inner layer. This material was used in the original installation of the bottom 36 ft of the lift pipe. In over three years of use to date, this section has shown no appreciable wear.

Evidence is that it was not failure of the heat-treated steel itself that caused erosion. Excessive erosion had occurred in areas where external travel guides were welded to the lift pipe. Also, the erosion had proceeded along the welded seams of the pipe and at joints where the 12 ft sections had been field-welded.

Amlico is justifiably proud of their most recent turnaround on the Thermofor catalytic cracking unit. Not content to let it ride, however, orders are now being processed for materials for another turnaround . . . scheduled for more than a year away. Such policy has paid them handsomely. The proof lies in the fact that the unit has operated 95.5 per cent of total days elapsed since the unit first went onstream a little more than three years ago. ★ ★ ★

part 2

exclusive

Catalytic Reforming Processes — Desulfurization — Isomerization — Polymerization — Lubrication via MoS_2 additives — Corrosion Resistant Alloys Various Alloy Types — Where Used —

MOLYBDENUM In Petroleum Refining

Benjamin H. Danziger and J. Richard Milliken
Climax Molybdenum Company

Reforming Processes

Commercial reforming processes employing molybdenum catalysts are fixed-bed Hydroforming, fluid Hydroforming and Orthoforming, and Hyperforming.

In fixed-bed Hydroforming,[11] the first commercial catalytic reforming process, toluene and high-octane gasoline are produced with pellets of molybdena on alumina as the catalyst.

Recycle gas containing about 70 per cent hydrogen keeps the reactor at a partial hydrogen pressure of 40 to 90 per cent. It is a cyclical process with two of the four catalyst cases on regeneration while the other two are on process. Regeneration with air diluted with flue gas at 1050 to 1100 F reoxidizes the partly reduced catalyst and removes sulfides that have reacted with the catalyst. There are now in operation 5 units with a total capacity of about 50,000 bbl per day. None has been built since the war.

Fluid Hydroforming[11] also employs a molybdena-alumina catalyst—a powder — to reform naphthas with a fluidized solids catalyst technique. The catalyst is not poisoned or lessened in activity by such contaminants as arsenic, iron or nitrogen. It is continuously regenerated at 1100-1150 F and pressure of 200 to 250 psi in a separate regenerator by burning to remove carbon and sulfur. Advantages of the fluidized-bed over the fixed-bed type lie in its superior heat-transfer rates that permit (1) lower reaction temperature and excellent temperature control of the exothermic reaction, (2) simple, economic catalyst regeneration, (3) lower investment and operating costs, (4) more efficient use of catalyst, (5) longer catalyst life, and (6) simpler reactor design.

The first fluid Hydroformer went on stream in mid-1953. There are now 11 units in operation or under construction in the world with a total capacity of over 140,000 bbl/day.[10, 11]

A modification of fluid Hydroforming, a process licensed by Esso Research and Engineering Company and M. W. Kellogg Company, is Kellogg's Orthoforming process. In this, the catalyst regenerator is integrated in a stacked, single-vessel design.

In Hyperforming,[12] Union Oil Company of California's new process, a catalyst of cobalt-molybdate on a silica-stabilized alumina base is used in a single-moving-catalyst-bed reactor. The solids are circulated by the unique Hyper-flow principle of mass conveyance, which moves the catalyst at very low velocities with minimum attrition loss. This catalyst is outstanding in its ability to withstand inferior stocks containing sulfur, nitrogen, and other contaminants troublesome to many catalysts. As the catalyst is mass-conveyed from the bottom to the top of the reactor, it is continuously regenerated by burning off the carbon with recycled flue gas containing less than 2 per cent oxygen. Even heavy coke deposits on the catalyst arising from unusual contaminants in the feed are easily coped with. One 1100 bbl/day semi-commercial Hyperformer is in operation.[11]

Other Catalytic Processes

Although desulfurization and reforming are the principal refining processes using molybdenum catalysts, the versatility of these compounds extends their use beyond these reactions. Among other applications used commercially or under extensive investigation are alkylation, isomerization, polymerization and oxidation.[12]

Both isomerization — one of the reactions that takes place in reforming — and alkylation are reactions yielding high-octane products, and molybdenum catalysts figure prominently in current work on them. n-Pentane, for example, with molybdic oxide on alumina as catalyst and at pressures of 250-500 psi, can be isomerized to isopentane, the yield varying from 50 per cent to 100 per cent depending on the mole ratio of hydrogen to hydrocarbon used. The same type of catalyst in the presence of hydrogen will alkylate aromatics with paraffins under reforming conditions. Alkylation of aromatics with olefins also can be accomplished with such catalysts as $CoMoO_2$, $CoMoO_3$, $CuMoO_3$, and $ZnMoO_3$:

Polymerization of ethylene and propylene occurs at temperatures of about 575 F and at 200 psi with a silica-molybdic oxide-phosphoric acid catalyst. Use of molybdenum catalysts in such reactions is now of primary interest in the preparation of low-pressure polyethylene, but this type of reaction has other potential applications as well.

Oxidation reactions catalyzed by molybdenum compounds are widely used in the manufacture of many chemicals from petroleum sources.

Among such commercial processes are the oxidation of methanol to formaldehyde and of benzene to maleic acid.

In the partial oxidation of methanol to formaldehyde, the catalyst is unsupported molybdic oxide and iron oxide. The reaction is carried out with an excess of air at temperatures of 435 to 935 F and atmospheric pressure to give a 95 per cent yield.

Addition of molybdic oxide to the standard vanadium pentoxide catalyst improves the oxidation of benzene to maleic acid or anhydride. This too is carried out in the presence of large excesses of air at a temperature of 800 F. In laboratory runs, 82 per cent conversion has been reported for a similar oxidation of naphthalene to phthalic anhydride.

Aliphatic hydrocarbons can also be used as the raw material for maleic anyhdride. At 890 F, a coprecipitated, cobalt molybdate catalyst promoted with boric acid gave a 60 per cent yield of maleic anhydride by oxidation of butane.

Molybdenum Disulfide Lubricants

Another molybdenum compound of great importance in refining operations is molybdenum disulfide, which is the answer to a number of difficult lubrication problems. This compound, used either as a dry lubricant, grease additive or suspended in liquids, combines unusual adherence to metal surfaces with low coefficient of friction and low resistance to shear, to give superior boundary lubrication. It functions over a wide range of temperatures, retaining its lubricity from —100 F to 750 F in air, and up to 2000 F in the absence of air. It resists pressures beyond the yield point of any metal and is practically inert chemically.

These properties find wide application where temperatures or pressures are too high for ordinary lubricants, where frequent servicing is impossible, to stop freezing and fretting of like metals (stainless to stainless, brass to brass), as an anti-seize treatment for threads, in breaking in new machinery, in the machine shop for tool and die treatment, and in forming, press and shrink fitting. Obviously, a refinery with its operations at high temperatures and pressures and unusual atmosphere has many such uses for moly sulfide lubricants. One familiar to all refinery operators is the use of molybdenum disulfide in oil as a treatment for reactor bolts to prevent seizing during disassembly. Others include applications in pumps, valves, packings and seals.

Molybdenum-Containing Steels and Alloys

Molybdenum-containing steels are standard materials of construction in the petroleum refining industry where they meet the principal requirements of corrosion resistance and high strength at elevated temperatures. Over the past 20 years or so, a whole family of steels ranging from carbon-molybdenum products up to stainless steel with molybdenum has been developed for different applications. Among these, the basic refinery steels are chromium-molybdenum materials with 1 per cent to 9 per cent chromium and 0.5 per cent to 1 per cent molybdenum.

The popularity of 1-9 per cent Cr, ½-1 per cent Mo steels is related to the primary characteristic of the refining industry that must be borne in mind in selecting materials for equipment—rapid obsolescence. There is no point of specifying stainless for a process that is going to have a technological life much shorter than that of the material of construction. Hence, the chromium-molybdenum steels are economical solutions for applications where the superior performance of a highly alloyed steel such as 18-8 with molybdenum, for example, is not required, but where something better in oxidation and corrosion resistance than can be had with carbon-molybdenum steels is needed. Similarly, if process temperatures are relatively low and there is no corrosion, the still cheaper carbon-molybdenum steel will be specified.

Corrosion Resistance and Strength

The function of chromium in these steels is to increase the corrosion and oxidation resistance at the elevated temperatures of refinery operations. Corrosion resistance improves with the amount of chromium added, but the degree of improvement will depend upon the corroding conditions. Resistance to oxidation also increases with chromium content. In any application, therefore, the steel must be selected with a sufficient chromium content to resist expected corrosion and oxidation conditions at the temperatures to be encountered.

The 4 to 6 per cent chromium-molybdenum steels are generally four to ten times as corrosion-resistant as carbon steel; the 7 per cent chromium-molybdenum steel is about twice, and the 9 per cent chromium-molybdenum steel is about four times as resistant as the 4 to 6 per cent chromium-molybdenum type.

With chromium steels, molybdenum is added to minimize temper brittleness, a need that was discovered when 5 per cent chromium steel was first used in still tubes in refinery service. When these tubes were cooled down for cleaning after prolonged exposure to high temperatures, they were so brittle that failures were common although original impact strength was high. The addition of tungsten or molybdenum proved effective in controlling such embrittlement, and 0.5 per cent molybdenum is now specified in practically all intermediate chromium steels. Subsequently, it was also found that the molybdenum increased high-temperature strength as well, so it actually plays a dual role in steels of this type.

Addition of molybdenum to chromium steels results in marked improvement in creep and rupture strength, the common measures of strength used in the design of equipment for high-temperature service. Generally about 0.5 per cent molybdenum is added, but larger amounts, up to 2 per cent at least, progressively increase the elevated temperature strength.

Selection of tubes and piping is commonly made on the basis of allowable loads at given temperatures set forth in standard codes such as the American Standard Code for Pressure Piping. These codes provide for rea-

TABLE 1. Allowable S values psi for pipe in oil piping systems within refinery limits.*

Material		ASTM specification	Grade	Minimum ultimate tensile strength	Values of S-psi for metal temperatures in deg F not to exceed		
					800	1000	1100
Carbon steel tubes							
Si killed	Seamless	A192	—	—	9,300	2500	1000
Si killed	Seamless	A210	—	60,000	10,800	2500	1000
	Seamless	A334	C	55,000	10,200	2500	1000
Carbon moly tubes							
Si killed	Seamless	A209	T1b	53,000	13,150	6250	2400
Si killed	Seamless	A209	T1	55,000	13,150	6250	2400
Si killed	Seamless	A209	T1a	60,000	14,400	6250	2400
Chromium moly tubing							
(1 Cr ½ Mo)	Seamless	A213	T12	60,000	14,750	7500	2800
(A200 Gr3)(1¼ Cr ½ Mo)	Seamless	A213	T3	60,000	15,000	7800	4000
(A200 Gr4)(2 Cr ½ Mo)	Seamless	A213	T14	60,000	14,700	6200	2750
(A200 Gr6)(2¼ Cr 1 Mo)	Seamless	A213	T22	60,000	15,000	7900	4200
(A200 Gr5)(3 Cr 1 Mo)	Seamless	A213	T21	60,000	13,900	7000	4000
(A200 Gr8)(5 Cr ½ Mo)	Seamless	A213	T5	60,000	12,800	7300	3300
(A200 Gr7)(7 Cr ½ Mo)	Seamless	A213	T7	60,000	12,500	5000	2500
(A200 Gr9)(9 Cr 1 Mo)	Seamless	A213	T9	60,000	12,800	8500	3300

* Extracted from Supplement No. 1 to the American Standard Code for Pressure Piping (ASA B31.1a–1953) with the permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, New York.

sonably certain protection of life and property and allow a margin for deterioration in service that insures a reasonably long safe period of use.

Table 1 shows the allowable working stress values for carbon-steel, carbon-molybdenum, and chromium-molybdenum tubes at different temperatures. It can be readily seen from these figures that the much higher allowable stresses can be used with carbon-molybdenum tubes than with carbon-steel tubes, and that the allowable stress of chromium-molybdenum equipment increases with increase in molybdenum content of the steel.

In a refinery, what is desired is a metal that will bulge before failure so that the operator will have sufficient warning to remove the tube or pipe and replace it with a new one. Molybdenum steels with 0.5 per cent molybdenum break with relatively low elongation, particularly at about 950 to 1000 F, when rupture occurs after a prolonged time period. The addition of chromium, however, minimizes this low ductility. Stress rupture tests with 0.5 per cent molybdenum steel, for example, showed an elongation of about 5 per cent for a fracture time of 1500 hr at 1000 F, but a 4 to 6 per cent chromium-molybdenum steel has an elongation of 48 per cent.

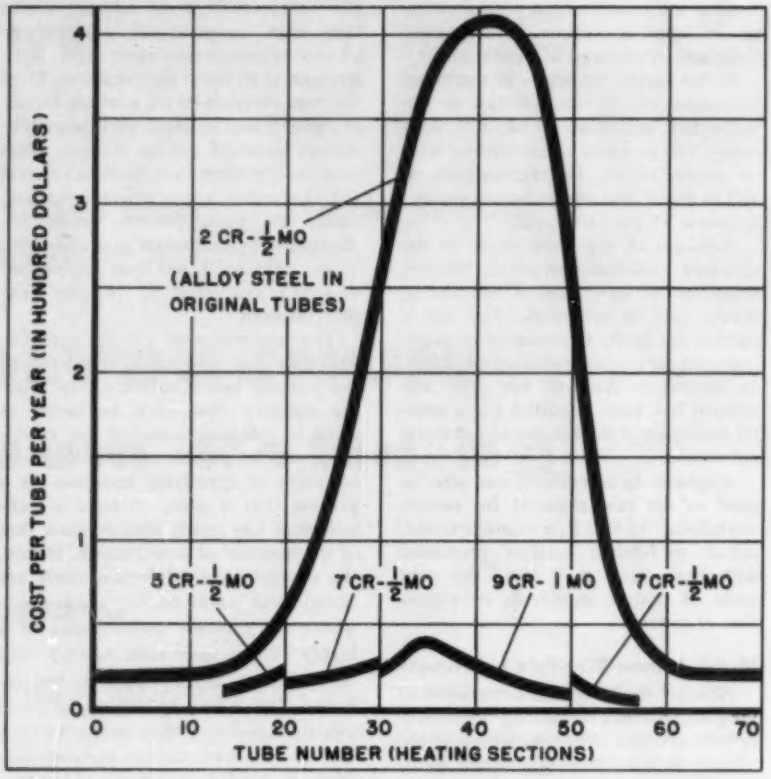


FIG. 5. Yearly costs for tubes of different alloy steels in service in different heating sections of a Polyform furnace operating on corrosive feed stocks.[14]

Economics of Selection

As has been previously mentioned, the selection of steel will be an individual problem based on the corrosion conditions and temperatures to be experienced in any given unit operating on a given feed stock. From that data, the strength that will be needed is then determined and the steel selected.

Often, however, the extent of corrosion may not be sufficiently realized and the selection of an alloy with insufficient resistance to corrosion may boost maintenance costs and cause undue down time.

In the case of a polyform unit,[14] 2 per cent Cr-½ per cent Mo was selected for the furnace tubes handling a very corrosive charge with a sulfur content of 0.4 per cent (weight) for the polyform furnace and 0.5 per cent for the unit's polymerization furnace. Since corrosion of tubes operating in the critical corrosion temperature range of 550 to 900 F became severe after start-up, these were gradually replaced with progressively higher alloy tubes. During the course of this replacement, corrosion rates of the different alloy steel tubes in service in different positions in the furnaces were determined, and these combined with their relative costs to give a comparison in cost per tube per year. (Fig. 5.)

These data showed that the yearly tube cost for the higher alloys (5Cr-½ Mo, 7Cr-½ Mo, 9Cr-1Mo) were all under $40 per tube, and some as low as $5, whereas about half of the original 2Cr-½ Mo tubes cost over $100 per year per tube, with many as high as $400. Replacing the original with higher alloys not only reduced corrosion and maintenance costs, but increased stream time from 30 to 60 days to 135 days.

Different Alloy Types

The high-temperature steel suitable for use in petroleum refining can be classified as carbon-molybdenum steels, chromium-molybdenum steels, and austenitic stainless steels.

Carbon-Molybdenum: In considering the carbon-molybdenum steels for refining applications, it was early recognized that their oxidation and corrosion resistance was no better than that of plain carbon steel. But carbon-molybdenum steel is suitable for higher stresses than carbon steel, where mildly corrosive conditions prevail.

The ½ per cent Cr-½ per cent Mo composition is interchangeable with the ½ per cent Mo, but is superior in respect to graphitization, and is probably the most popular composition of this type. Higher molybdenum content further increases the strength, especially at temperatures above 1000 F. However, since surface stability is not improved, this greater strength cannot be exploited unless the surface can be protected from corrosion and oxidation by some other means. Nevertheless, these materials are used for oil refinery heaters, oil still tubes, heat exchangers, reactor and pressure vessels and for miscellaneous high-temperature piping where corrosion is not severe.

Chromium-molybdenum steels: Among the low-alloy chromium-molybdenum steels, use of the 1¼ per cent Cr-½ per cent Mo and 2 per cent Cr-½ per cent Mo compositions has been declining over the past few years. This is due in part to the increasing severity of operating conditions, with higher temperatures and pressures more corrosive feed stocks; in part to the generally greater overall economy of 2¼ per cent Cr-1 per cent Mo composition. The 2¼ Cr-1Mo alloy has been adopted, and is being used in increased quantities, for high pressure work in such processes as thermal reforming, polymerization, alkylation and deep cracking of non-corrosive stocks. The 3Cr-1Mo composition gives somewhat more corrosion resistance than 2¼ per cent Cr-

1Mo, but it is not suitable for as high-working stresses.

The 4-6 per cent Cr steels, which were introduced because of their superior corrosion resistance in hot petroleum products, were the forerunners of the whole class of chromium-molybdenum steels. These now contain ½ per cent molybdenum, as has been explained, to minimize embrittlement and increase high-temperature strength.

The 5Cr-½ Mo alloy has good resistance to oil corrosion and is a standard steel widely used for refinery tubing applications in both furnace tubes and piping. It can withstand fairly high working stresses and has reasonably good resistance to oxidation.

In a heat exchanger used in a combined distillation and cracking service in one refinery, .095 in. wall carbon-steel tubes failed by pitting and general corrosion after service life of less than a year. In this unit, the operating pressure was 250 psi inside tubes and 320 psi outside tubes. The interior crude petroleum contained 0.25 to 0.5 per cent organic sulfur and external gas oil, 0.6 to 0.8 per cent organic sulfur compounds. Temperatures were —5 to 750 F (average 525 F.) Present tubes of 5Cr-½ Mo have been in service for 3 years with an expected useful life of 4 to 5 additional years.

Higher chromium steels of 7 per cent and 9 per cent chromium are modifications of the 5Cr-½ Mo type with the high chromium content designed primarily to increase corrosion resistance in hot petroleum products. Some refinery results indicate that, under their specific conditions, the corrosion resistance of the 7 per cent Cr-Mo steel is more than five times that of 5Cr-½ Mo, and that of the 9Cr-1Mo steel, about six times. While the magnitude of improvement may vary, it is known that these steels are giving satisfactory service in applications in which the regular 5Cr-½ Mo was unsatisfactory.

An increase in the molybdenum content to 1.0 per cent is beneficial in both the 7 per cent and 9 per cent chromium steels, although even at this higher molybdenum percentage, both possess creep characteristics very similar to 5Cr-½ Mo.

Austenitic Stainless Steels

Use of austenitic stainless steel in both oil refining and petrochemical plants is continuing a rapid growth. Chief reasons for this trend are the increasingly severe service conditions requiring their good oxidation and corrosion resistance, and high creep strength; the relative ease with which they can be welded and fabricated, and their relative economy compared to some non-ferrous materials. Molybdenum was one of the earliest alloying materials to be added to the so-called 18-8 type. In these steels also, molybdenum increases working stress capabilities particularly at temperatures above 1200 F.

In many applications involving borderline conditions for regular 18-8 stainless, the molybdenum and copper-molybdenum types quite satisfactorily extend the range of permissible operation. Under the most severe conditions, especially with hot, concentrated vapors or condensate, the molybdenum-bearing grades show definite superiority. Their resistance to pit-type corrosion is also notably superior.

An example of a condition calling for something superior to regular 18-8 would be the presence of a hydrochloric acid-water phase in the relatively cold top sections of distilling columns. This would develop when HCl is formed from hydrolyzable salts in the crude oil during heating in the evaporation furnace. Bubble caps and trays of type 316 (2-3 per cent Mo) give satisfactory service here, whereas regular 18-8 stainless would be inadequate.

When salt water is a medium in admixture with other chemicals, it is sometimes necessary to use type 317 (3 to 4 per cent Mo), a steel with a higher molybdenum content than type 316 (2 to 3 per cent Mo). An interesting example is found in a refinery plant reboiler where the sulfur dioxide water in the system was reboiled in the presence of chloride ion. Under such severe conditions, type 316 fails with signs of pitting, but type 317 does the job.

Sometimes only slight changes in environment will change stainless steels from the passive to the active state or vice versa; consequently, conditions of so-called "borderline passivity" can cause unpredictable variations in resistance to general corrosion. Dilute sulfuric acid solutions, especially when hot, are notorious in this respect. Both type 316 and 317 give increased resistance to dilute sulfuric acid corrosion over regular 18-8. Copper-molybdenum compositions, however, give substantially improved corrosion resistance, particularly where sulfuric acid is involved.

Cast alloys corresponding to all the above wrought grades are also available and are used extensively in refineries in such applications as fittings, valves, return bends, pumps, etc.

The discovery that there is a sharp drop in corrosion loss at about 18 per cent molybdenum in nickel-molybdenum alloys led to the introduction of a series of nickel-base alloys containing varying amounts of molybdenum and having varying corrosion resistance. These have had wide application for extremely severe corrosion conditions throughout industry. In petroleum refining and petrochemical manufacture, they are used principally in handling hot or boiling sulfuric acid, halide acids, and acid halide salts.

Construction Applications

Although the use of molybdenum alloys in applications requiring corrosion resistance and strength at high temperatures is molybdenum's most important role in refining operations, it also contributes strength to constructional alloy steels. This property is exploited in high-temperature bolts, pump shafts, and miscellaneous machinery.

Moreover, the use of low-carbon, heat-treated contructional alloy plate for pressure vessels and tubing is now being investigated. If successful, these alloy steels will further broaden molybdenum's usefulness in the industry, for it is also added as a hardening agent to these steels.

What's Ahead

Technological advances in the petroleum refining industry have made its requirements for raw materials such as catalysts, lubricants, and alloys for plant equipment increasingly stringent in recent years.

This trend should continue with the development of new processes operating at higher temperatures and pressures, frequently under corrosive conditions, and calling for more effective catalysts.

Molybdenum's unique and versatile properties should meet many of these requirements and further extend its usefulness in petroleum refining.

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★ ★ ★

II. Selecting Equipment

L. Planned Refinery Lubrication — A Management Opportunity

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PLANNED refinery lubrication programs are rapidly replacing the "old timers" motto, "Give it more oil—we make lubricants, not machine parts." This trend has resulted from the growing complexity and importance of proper lubrication in a refinery. By means of such programs, more efficient, uninterrupted operation of all types of equipment is being obtained, adding greatly to profitable refinery operation—the major objective of management.

This article describes the basis for a practical, efficient program, one that has been tried and proved in many refineries both large and small. It has given results that have exceeded all expectation of management through reduction of maintenance labor, replacement parts, and lubricant costs. Basically, the successful application of planned lubrication is dependent upon three factors:

1. Management recognition and backing.
2. Development of a workable organization.
3. Use of up-to-date technical information.

In each of these fields, practical experience has developed several basic guides that will be helpful to any refiner desirous of improving lubrication practices.

Management Recognition

At no point in any program is success more delicately balanced than upon proper recognition, backing, and delegation of authority by top management. In the complex organization of a modern refinery, a simple, clear, and concise expression of the manager's continued interest in improving the reliability of equipment through a competent lubrication program is the greatest single aid in promoting its acceptance. The first step in this respect is to announce an established policy defining the objectives and designating the person responsible for its proper execution. Normally, authority is delegated to one individual, the choice of whom will vary with different refineries. It may be an engineer with no other responsibilities, a maintenance superintendent or foreman, or an operating superintendent or foreman. No matter who the choice, this individual is recognized as the final authority on matters of lubrication.

A typical organization is shown in the attached chart (Fig. 1) in which the lubrication supervisor's position is not unlike that of a wheel hub. He plans, coordinates, and guides all efforts pertaining to lubrication. Success or failure of the program is in his hands. In addition to his direct contacts with refinery personnel, it is necessary for the supervisor to have the authority to consult directly with laboratory and marketing department lubrication engineers, the former for product information and evaluation of samples submitted for analyses and the latter for their practical experience and technical guidance.

In this breadth of contacts by the lubrication supervisor in consulting and guiding individuals not directly working for him lies a basic problem for management in obtaining an effective lubrication program. Management's second important responsibility, therefore, is to select the proper type of man—aggressive, competent, but above all, capable of influencing others. This person must realize that his authority lies in his knowledge of the problem, together with management's close interest rather than through an arbitrary position of direct supervision. It is management's job in promoting the program to keep these factors in mind in the selection of a lubrication engineer or supervisor.

In turn, to insure continued support by management, the lubrication supervisor has a responsibility for periodically evaluating the productivity of his efforts. Decreased lubricant consumption, lower maintenance costs, and increased equipment utilization are all measures of effectiveness to be studied.

Organization and Training

The second most critical phase in any planned lubrication program is the development of an effective working organization. Having obtained management backing, the details of Who will do What, How, and When become the responsibility of the lubrication supervisor. As the objective of the program is decreased operating expenses, these functions must be fitted into the present refinery organization without the employment of additional personnel. This

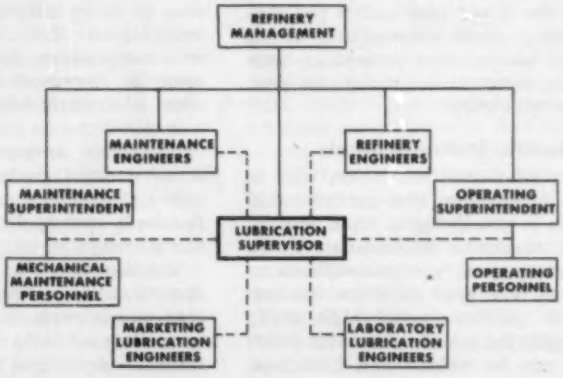

FIG. 1. Typical organization chart.

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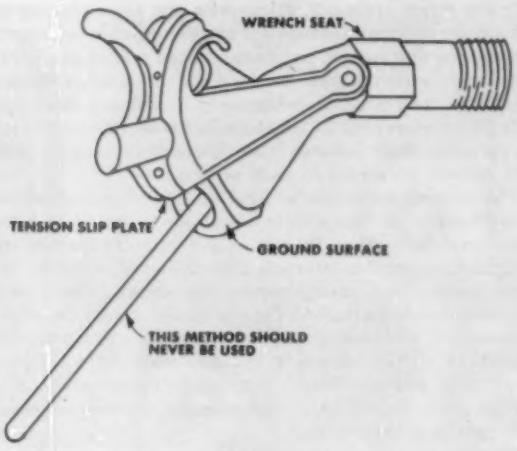

FIG. 2A. Oil drum "molasses cocks" and improper methods for handling them.

FIG. 2A. OIL DRUM 'MOLASSES COCKS'

These cocks are as precisely made as any other valve as far as the seating parts are concerned. The semicircular slip plate located in the movable part of the handle is under spring tension and presses the slip plate firmly against the ground joint seat on the valve body. By closely lapped fit between the slip plate and the seat on the valve body, a non-leaking fit seal is made.

On the threaded end of the "molasses cock," there is a hexagonal-shaped part where a suitable wrench can be applied for tightening cock into oil drum or for unscrewing.

If one should use a rod on a piece of pipe inserted in discharge port (as shown in sketch) for the purpose of tightening the cock or for unscrewing, the thrust sideways would create a burr on the seating surface that would ruin the "molasses cock."

Do not use anything but a wrench in the inserting or removal of the cock.

FIG. 2B. FORCE-FEED LUBRICATORS

"The heart that prolongs the wearing life of any machine is lubrication."

A force-feed lubricator is a precision machine that has a quantity regulating piston "A," a positive high-pressure piston "B," a suction screen "C," and steel-ball check valves located in body at "D."

The pumping unit in the lubricator has very close running tolerances. To protect the closely fit parts, the oil-level gage glass must be kept clean both on the inside and outside so that any accumulation of condensate within the lubricator can be detected and drained by removing the ¼-in. pipe plug from the bottom of lubricator housing.

If water is allowed to accumulate within the lubricator, closely fit moving parts become corroded and cease to function. In turn, the lubricator and the machine being lubricated will be subjected to unnecessary wear.

Sight-feed glass cover must be kept clean at all times so you can see that the correct amount of oil is being delivered.

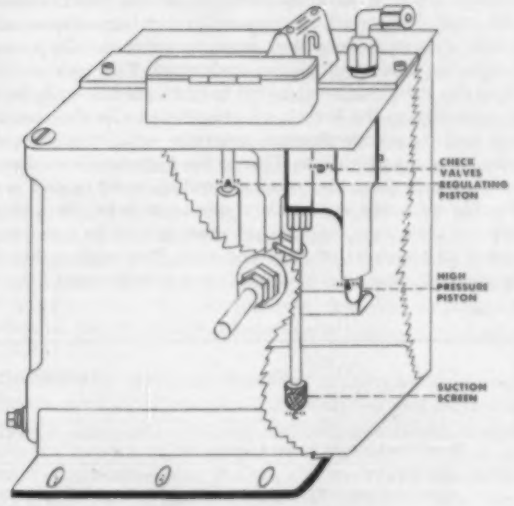

FIG. 2B. Diagrammatic sketch of a force-feed lubricator.

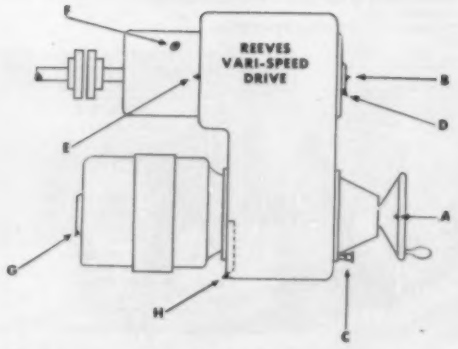

FIG. 2C. Vari-speed drive and its lubrication points.

FIG. 2C. LUBRICATION OF OLIVER FILTER AT TCC GAS OIL TREATER

Insert three strokes of grease from gun provided into grease connections (A) and (B). Use Mobilgrease MP. (Twice per month.)

Insert three strokes of grease every 60 days in connections (D) and (E), using Mobilgrease MP.

Insert two grease cupfuls twice per week at connection (C) using Mobilgrease MP.

Maintain oil level in gear case at marked level on gaging rod located on top of gear case (F), using DTE XH.

Grease connections (G) and (H) that supply grease to motor bearings are to be lubricated by the electricians.

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problem has been solved at one refinery through the use of several principles as discussed below.

1. **Subdivide refinery unit areas into small sections.** Inherently most refineries are divided in one form or another into broad unit areas where many pieces of equipment are scattered over a large area. To obtain thorough lubrication coverage, these areas must be subdivided into smaller sections and responsibility delegated to individuals (one each shift) in each section. Through this technique, equipment lubrication is only one of many duties delegated to one individual, eliminating the need for additional personnel. The practicability of this technique is demonstrated in one large refinery that is carrying out a planned lubrication program with a marked degree of success. This refinery is divided into two large areas each supervised by a foreman. These areas in turn are divided into seven unit areas, each with refinery engineering supervision. The units are further divided into 30 sections for flexibility of operation, maintenance, and lubrication. The foreman and engineers work closely with the lubrication supervisor, who primarily deals directly with the lubrication personnel in each section.

2. **Personnel must be trained.** This portion of the program may be considered as being perpetual and is the greatest challenge to the lubrication supervisor. Experience shows training to be dependent upon three personal characteristics — he must be a salesman, teacher, and engineer if results are to materialize from his efforts. While discussions must be carried on frequently with supervisors and section personnel, reminders must be continuously passed along to the men handling the equipment. This task is difficult as the individuals delegated to lubricate the equipment are generally of the lowest job classification in the specific areas and personnel changes generally occur continuously in the lower classifications. Due to the high turnover of personnel in such jobs, the training methods must impart considerable information in a short period of time. Obviously, a regular classroom training program cannot be scheduled because of elements of time and cost. Two approaches to this problem, however, have been successfully used.

In the direct approach, discussions and talks relating to lubrication and maintenance are carried on with engineers, supervisors, and section personnel. In the case of engineers and supervisors, this can be done individually as it may pertain to their area or collectively in refinery meetings. This information finds its way back to the section personnel. On occasion, short informal discussions may even be held with several personnel in each section.

The indirect approach, as used by one of our refineries, is so effective that this article would not be complete without a brief description. Posters in the form of sketches are originated at regular intervals and displayed much in the same manner that safety posters are shown. Three such posters are shown attached. One (Fig. 2A) shows the effect of installing molasses gates improperly in oil drums, the second (Fig. 2B) shows a cutaway view of force-feed lubrication, and the third (Fig. 2C) a detail study of a vari-speed gear unit. All posters carry a message along with pertinent information.

The majority of oil companies have well organized lubrication marketing departments that compile technical information on lubricants and equipment for educational purposes. Usually this information is presented in a simple, concise manner and is interesting reading. This type of literature has been passed out to refinery personnel in just the right doses so as not to be overwhelming, with the result that personnel look forward to receiving them. The net result is the training of personnel with a minimum of effort.

3. **Post charts of lubricant recommendations.** No matter how effectively training programs are conducted, individuals cannot remember specific details for any length of time. The preparation of lubricant charts for each section is an effective program aid. Every effort should be directed toward clarity, simplicity, and brevity in the preparation of these charts. One such chart (Fig. 3) is shown attached for a catalytic cracking area. The chart is simple and readily understandable to all personnel regardless of classification, is brief (one page) so that it may be read quickly, and

LUBRICATION INSTRUCTIONS
TCC UNIT

General: Operators shall check all lubrication points on all equipment once each shift and apply designated lubricants in accordance with these instructions. All reservoirs shall be checked for moisture and water drained if present.

CODE	EQUIPMENT	LUBRICANT APPLICATION
1	ELECTRIC MOTORS	DTE-HM—Check and notify electricians when bulb oilers are ⅔ empty and oil levels in reservoirs are below marked height. Electricians shall also lubricate bearings requiring grease. Ref: Instruction Pamphlet to operators.
2	STEAM TURBINES HAVING OIL RING RESERVOIR	DTE-XH—Maintain reservoir oil level at marked height on gage glasses. Hand oil governor linkage and trip mechanism.
3	STEAM TURBINES HAVING FORCED-FEED LUBRICATION	DTE-LT—Maintain reservoir oil level at marked height on gage glass.
4	CENTRIFUGAL PUMPS	DTE-HM—Refill bulb oilers when half full. Maintain oil level at marked height on reservoir.
5	CENTRIFUGAL PUMPS HAVING FORCED-FEED LUBRICATION	DTE-HM—Maintain level in force-feed oil reservoirs at marked height. Check oil pressure to bearings. Immediately report any unusual pump noise.
6	RECIPROCATING PUMPS	Super Cylinder Oil 600 W—Keep forced-feed lubricators full and sight glasses clean. Lubricate with 6 to 8 drops per minute. Hand oil or grease linkage.
7	GEAR CASES	DTE-XH—Maintain oil level in gear case at marked height on gage glass or yellow marked plugs.
8	CRANK CASES	DTE-HM—Maintain oil level in crank case at marked height.
9	GREASED FITTINGS	Mobilgrease MP—Screw down grease cups three turns. Inject 3 shots in grease fitting.
10	OIL CUPS	DTE-HM—Maintain oil level at marked height.

MOTOR NO.	ITEM NO.	CODE	SERVICE	MOTOR NO.	ITEM NO.	CODE	SERVICE
413	4G11	1-4	TCC Liquid-Feed Pump	420	4G7	1-4	Heavy Gas Oil Pump
404	4G17	1-4	Cold-Topped Crude Pump No. 2	416	4G4	1-4	Light Gas Oil Pump
411	4G13	1-4	Cold-Topped Crude Pump No. 1	425	4G20	1-4	Circulating Water Pump
403	4G1	1-4	Separator Charge Pump	406	4G15	1-4	Boiler Feed Pump 450#
422	4G19	1	Wash-Gas Exchange Pump	Turbine	4G15A	2-4	Boiler Feed Pump 450#
405	4G14	1-4	Tar-Separator Bottoms Pump	423	4G16	1-4	Boiler Feed Pump 150#
412	4G5	1-4	Intermediate Reflux Pump	Steam	4G16A	6-10	Boiler Feed Pump 150#
Turbine	4G9A	2-4	Intermediate Reflux-Pump Spare	424	4G10	1-4	Sour Water Pump
407	4G9	1-4	Quench Pump	419	4G3	1-4	Reflux Pump
421	4G8	1-4	Bubble-Tower Bottoms Pump	Turbine	4G3A	2-4	Reflux Pump Spare
Turbine	4G8A	2-4	Bubble-Tower Bottoms Pump Spare	429	4G18	1-4	Gland Oil Pump
410	4G6	1-4	Recycle Pump	Turbine	4G18A	2-4	Gland Oil Pump
401	4K1	1-8	Combustion and Air Lift Blower	Turbine	5KT-1	2-9	Cooling Air Fan
				Turbine	4K2	3-8	Wet Gas Compressor
		7-9	Fresh Catalyst Elevator Equipment				

FIG. 3. Typical instruction sheet for lubricating a TCC unit.

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FIG. 4. Set of oil dispensers that have been made standard in the senior author's refinery.

FIG. 5. Oil dispenser cabinets like this are installed at each plant unit.

clear to the point that instructions will not be misunderstood. These lubrication charts should be posted in a prominent location in each of the section areas, and should contain information pertinent only to the equipment in that section.

4. **Use proved lubrication aids.** Generally, the less frequently a piece of equipment must be lubricated the greater the protection. Requiring constant vigilance on the part of an operator is an unrealistic demand that can be eliminated by the use of mechanical devices. Force feed lubricators, bottle oilers, oil and grease reservoirs to increase oil or grease capacity greatly minimize the danger of marginal or loss of lubrication. In addition, the total amount of contaminants that enter the equipment with oil servicing will be greatly minimized with these devices. Improved lubrication service may be obtained with such practical aids as (a) placing readily visible markers on sight glasses to check oil level at a glance, (b) use of carefully tested solutions in mechanical sight feed glasses, and (c) the use of a button head and smaller fitting for the application of two different types of grease.

The use of suitable dispensing equipment and storage facilities are aids that merit consideration. After a study of the various applications it has been found that three dispensers of the closed type shown in Fig. 4, along with one or two grease guns, will satisfactorily take care of all lubrication needs. Generally, this apparatus is standardized in the refinery. To keep the dispensers out of the weather and to minimize contamination, a cabinet such as shown in Fig. 5 is recommended. The cabinet includes a hot plate (steam coils) to keep cylinder oil warm thus removing the dispenser from pump steam chests, which generally are in the open. A shelf is also provided for clean oil rags.

5. **Provide suitable oil storage.** The construction of suitable oil drum racks in each unit area is another step in efficient organization. Figs. 6 and 7 show drum racks of various sizes that have proved to be very satisfactory. The racks were fabricated out of salvaged heater tubes and are of sufficient size to hold a four-day supply of any one grade of oil used at the unit area. The racks are so designed that the drums slope from the horizontal just enough to empty completely thereby reducing waste. This design also minimizes water contamination that often occurs through the bung holes. The legs of the rack are set in concrete for rigidity and a drain trough covered with wire mesh is rigidly installed so that the dispensers may rest on it. This trough is slightly sloped for drainage purposes and is connected to an oil recovery system. In addition to improving the appearance of the surroundings, this type of structure eliminates the hazards that generally accompany oil-soaked grounds.

6. **Minimize lubricants handling.** A suitable lubrication program must include a plan for scheduling and delivering drums of lubricants from the refinery warehouse to unit areas. Normally such delivery cost is high as it involves the time of a number of men, the use of a truck, and some form of lifting device. Without a plan and schedule, these men and equipment are generally occupied a large portion of each day delivering lubricants.

These costs can be greatly reduced, however, with a planned delivery schedule. Deliveries can be made to areas bi-weekly, on Tuesdays and Fridays for example. All orders for lubricants must be placed in the dispatchers' hands the afternoon of the preceding day. Sufficient oil is ordered at

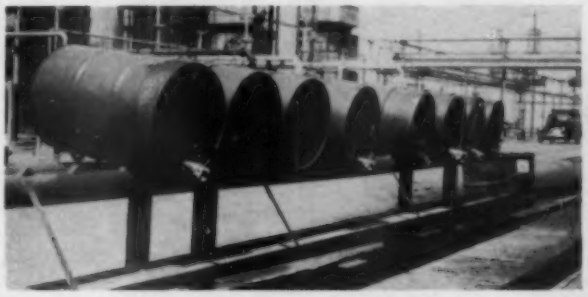

FIG. 6. Home-fabricated oil rack in the plant, showing drums in place and "molasses cocks" installed.

FIG. 7. Rack at catalytic cracking units, similar to Fig. 6.

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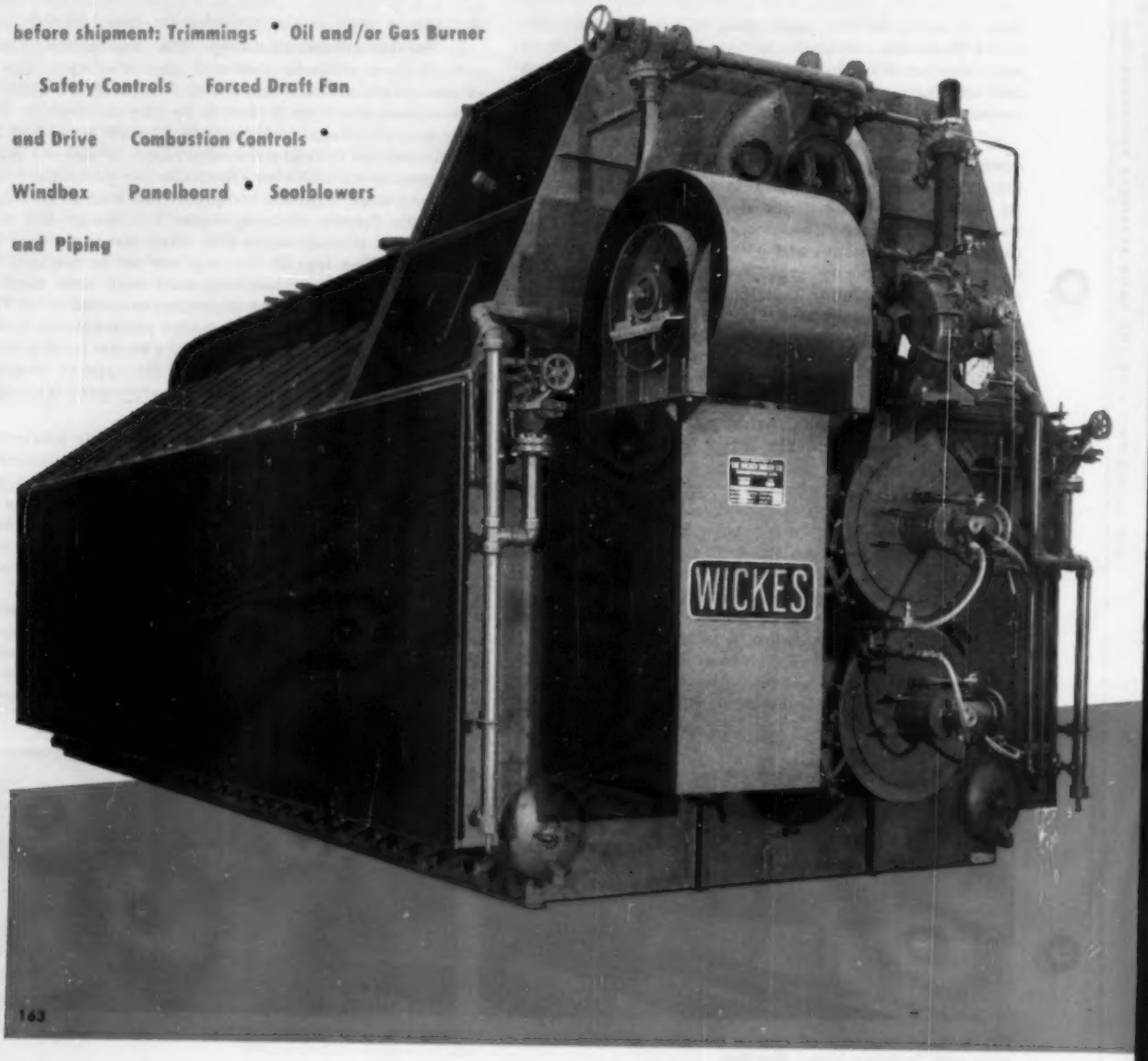

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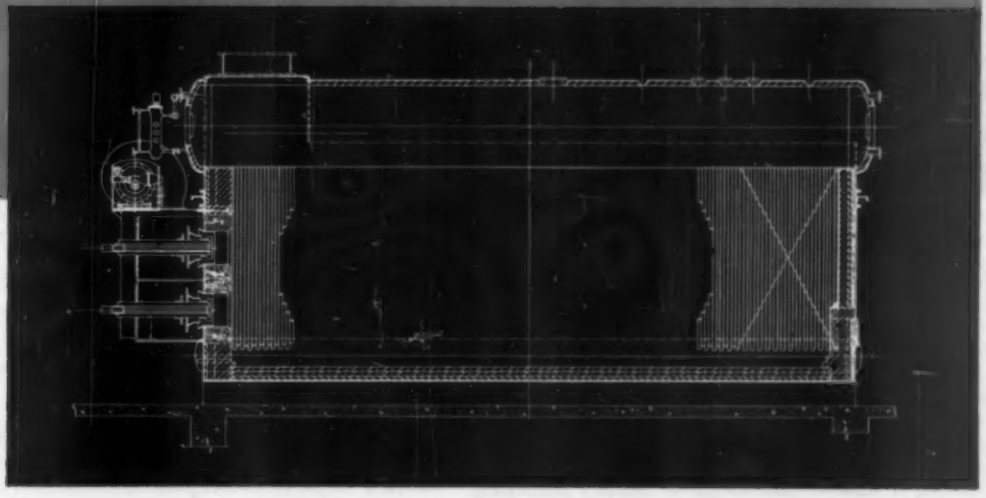
HOUR WITH A SHOP-ASSEMBLED STEAM GENERATOR



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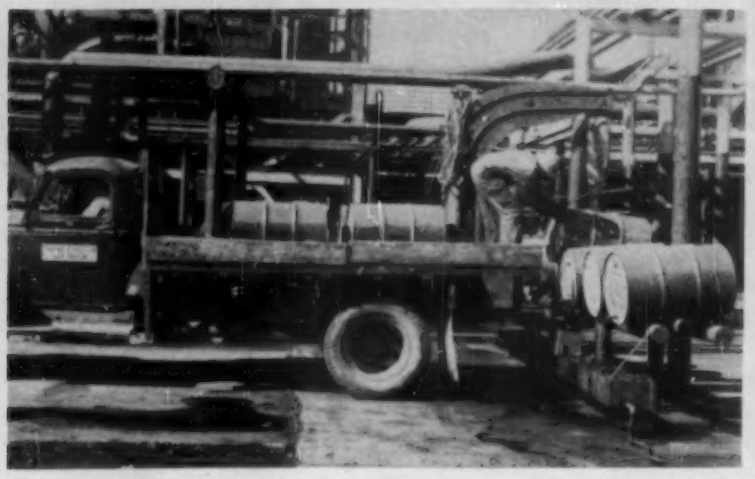

FIG. 8. Method of delivering lubricating oil drums to plant rack from a platform truck.

FIG. 9. Right, mileage recorder for lubrication record on refinery or other trucks.

that time to carry the areas through the intervening days. By using a flat bed truck equipped with a winch and swinging boom, as shown in Fig. 8, the complete delivery operation can be accomplished with but two men. This regularly scheduled delivery system has an added advantage of maintaining a minimum of lubricant inventory. The practice of maintaining extra drums of oil in each unit area for standby can be eliminated. With the central warehouse maintaining a suitable inventory, the refinery purchasing department and the lubricant supplier will not have to face the problem of rush orders or large fluctuations in lubricant demand.

Technical and Supervisory Control

To obtain the full benefits from a trained and efficient organization, a planned lubrication program must be based upon up-to-date technical information regarding equipment requirements and lubricant capabilities. Each year equipment is faced with increased work loads, higher pressures, higher temperatures, and higher concentrations of corrosive elements. At the same time, the petroleum industry is developing improved lubricants such as inhibited turbine oils, high detergency engine oils, and high temperature greases. Maintaining up-to-date lubricant recommendations that compensate for more critical operating conditions and that utilize new lubricant developments is a continuing challenge for the lubrication supervisor. Probably the greatest single aid in this problem is the use of periodic consultations with field lubrication engineers of reputable oil suppliers. Even if the lubricants are manufactured at the same refinery, the guidance of your company's marketing personnel can be invaluable in establishing up-to-date lubricant recommendations. At one refinery the following steps have been used to provide proper technical control.

1. **Select the right lubricant.** To establish a sound program, operating conditions and current methods of lubricating each piece of equipment must first be studied, preferably by conducting a survey of all plant equipment. Many pieces of equipment and operating conditions are duplicated many times over, consequently the job is not as large as it first appears to be. Data necessary to select the right lubricant should include:

   1. Equipment identification.
   2. Type of service and duty.
   3. Operating loads, speeds, and temperatures.
   4. Method of lubricant application.
   5. Type of bearings.
   6. Manufacturer's lubricant recommendations.
   7. Lubricant currently in use.

In conducting the survey, care must be exercised not to overlook a single piece of equipment. Quite often for instance, a motor or blower may be overlooked because it is not visible. Enlisting the help of personnel who are familiar with the equipment in their respective areas not only expedites the completion of the survey but is reasonable assurance of thoroughness. From these data and with the assistance of lubricating engineers the lubricants necessary for plant lubrication can be listed. Generally, the results of the survey will disclose irregular lubrication procedures and even the use of the wrong lubricant in some instances.

2. **Minimize the number of lubricants used.** There are two primary reasons why the number of lubricants, in a plant, should be kept to a minimum consistent with good lubrication practices.

   1. It will keep inventories to a minimum thereby effecting a substantial savings in handling and storage costs.
   2. It will minimize the possibilities of product misapplication, which often results in increased maintenance and replacement costs.

Experience has shown that although no compromises can be made on quality and type of lubricant, a compromise can generally be made as to the viscosity grade of lubricants to be used. The grades of lubricants listed as a result of the survey above can therefore be reduced. Experience has shown that the number of lubricants necessary to lubricate refinery equipment generally can be reduced to about ten. These are listed in the following classification.

1. Premium circulating and turbine oils:
   1 — Light
   2 — Heavy medium
   3 — Extra heavy
2. Steam cylinder oil.
3. Greases:
   1 — Multipurpose
   2 — Ball and roller bearing
   3 — Multipurpose plug valve grease.
4. Heavy duty engine oil, SAE 30.

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5. Hypoid gear oil.

6. General purpose oil.

In rare instances where peculiar operating conditions are sometimes found, it may be desirable to augment this list with special lubricants. For example, in one refinery extreme difficulties were being encountered with stuck piston rings in a gas compressor. The high sulfur gases being used as fuel resulted in excessive ring zone carbon deposits. Use of a Series 2 lubricating oil tripled the operating life between overhauls.

3. **Establish proper drain intervals.** Inherently, refinery equipment is exposed to the elements and generally is in an environment of high humidity. Because of the increased amount of contamination, drain periods are usually scheduled at closer intervals than normally would be necessary. To establish drain intervals correctly, the services of the laboratory should be enlisted. (The visual and feel method of analyzing oils has been discredited long ago.) Once correct drain periods have been established, they will generally remain unchanged unless operating conditions are altered. Great care and good judgment must be exercised in selection of samples for analysis. It is quite possible to establish a drain period during a summer period that would not be desirable during wet winter operation as far as the condition of oil is concerned. Oil analysis must be conducted on oil samples during the period of most unfavorable operating conditions. It is quite probable that drain intervals may be established every three months during the summer and monthly during the wet winter months.

A particular problem is faced with equipment in intermittent service such as towmotors, lift trucks, and compressors. Often such equipment is not used for days and then is suddenly switched to an unscheduled overtime shift making records of service history difficult to maintain. In several installations, the use of a vibration recorder (Fig. 9) has proved invaluable in recording actual service history. Individual service records are summarized daily by the maintenance group that subsequently schedules oil drains, repairs, etc., for each piece of equipment according to the established schedules.

4. **Minimize oil usage.** Minimizing the usage of oil not only will result in a direct saving in lubricant cost, but can also improve the reliability of equipment. Obviously, good daily records of oil consumption by individual equipment are extremely useful in quickly showing excessive users of oil. A check of the equipment will disclose whether the increased usage is actually increased oil consumption or simply oil waste due to mechanical reasons. In fact, one of the best indications of mechanical condition for automotive and industrial engines is the rate of oil consumption. By periodic comparison of consumption records, the lubrication supervisor can greatly assist the maintenance foreman in discovering failing equipment.

A major source of failure for electric motors can be attributed to over-oiling. This problem has been avoided in several refineries by requiring that electric motors be lubricated by electricians only (Note Fig. 3).

It has been determined that the greatest source of oil waste is attributable to high rates of feeds of mechanical force feed lubricators. Maintaining oil levels too high in crankcases, gear cases, and oil baths is another source of oil waste than can be discovered by comparison of consumption records for similar pieces of equipment in various parts of the refinery. In addition to wasting oil such practices frequently lead to operating problems such as carbon deposition on compressor valves, overheating of gear cases, fouling of spark plugs, etc.

5. **Evaluate service problems.** With the proper technical experience and background, the lubrication supervisor has an important responsibility to assist management in improving current operating practices, and in planning future developments. By intimate knowledge of the operating demands, efficiency and flexibility of virtually every piece of operating equipment, unusual problems can be eliminated or avoided. In one refinery inadequate lubrication was blamed for an epidemic of engine failures in lift trucks. Careful investigation of these "lubrication failures" revealed the units to be overloaded requiring overspeeded engine operation that resulted in failures. Future replacements for the fleet were designed for the higher loads and resulted in excellent depndable service histories in the same operation.

Conclusion

The lubrication supervisor has an ever unfinished task calling for continual interest in refinery processing changes, operating schedules, and equipment replacement. He must keep abreast of technical lubrication improvements and convert this information into up-to-date practices. He must demonstrate that such a thorough program has a high place in improving refinery operation and reliability in order to merit management's continued recognition and backing. Management should recognize the direct profitability of thorough maintenance and lubrication programs as evidenced by the lack of unscheduled equipment problems.

The Authors

V. M. Stanich

G. W. Pusack

With a BS in mechanical engineering in his hand, V. M. Stanich started out to conquer the world in 1931 from Montana State College. He taught high school mathematics until 1934. Then he helped the Army Engineers, as a junior mechanical engineer, for three years, to build Fort Peck Dam in Montana. In 1937 he went to work for General Petroleum Corporation, his present employer. After World War II, Stanich returned to laboratory research and refinery engineering, researching in lubricating oil. He served as chairman of the company-wide lubrication committee. In 1954, he was promoted to chief engineer of General Petroleum's new Ferndale, Washington, refinery, which position he now holds.

G. W. Pusack is a graduate of the University of Michigan with a BSE in aeronautical engineering and mathematics. He received his MS in mechanical engineering from the University of Pennsylvania. From 1942 through 1945 he was project engineer for the U. S. Navy at Philadelphia Aeronautical Engine Laboratory mainly working on flight test and laboratory projects involving performance of fuels. After service in the U. S. Air Force at Wright Field, Ohio, during 1946, he joined Socony Mobil Research and Development Laboratories in Paulsboro, New Jersey. Between 1946 and 1953 he worked as development engineer on fuels and lubricants for automotive engines. In 1952, he was advanced to research associate in charge of programs to formulate improved aviation, automotive, and industrial engine oils.

Pusack was transferred in 1953 to the domestic marketing department, New York City, as staff engineer in the gasoline and fuel oil department. During 1955-56 he served as vice chairman for fuels and lubricants of the SAE Metropolitan Section in New York City.

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Gasoline: Motor Fuels

Chapter XIII

V. A. Kalichevsky
Consulting Chemical Engineer

THE largest portion of crude oil is utilized as fuel. The greatest demand is for gasoline. This may be visualized from the data presented in Table 1, which shows the volumes of various products obtained in proportion to every 1000 bbl of gasoline produced:

TABLE 1. Quantities of Petroleum Products Obtained to Every 1000 bbl of Gasoline Produced.

Product	Quantity, bbl	Percentage
Gasoline	1000	43.3
Kerosine	99	4.4
Lubricants	33	1.5
Asphalt and road oils	64	2.8
Fuel and gas oils	860	38.0
Wax	3.2	0.2
Miscellaneous	202	9.0
Loss in refining	18	0.8
Total per 1000 bbl gasoline	2279.2	100.0

However, the quantities of materials have no relation to profits derived from their sales. The margin of profit is considerably greater for products approaching the class of specialties and, particularly, petrochemicals than for those sold as fuel.

About one-half of the crude oil is consumed for operating automobiles. Average yearly consumption is 750 gal of crude oil per vehicle. The relative quantities of the various petroleum products used by the motorists may be approximated as follows:

TABLE 2. Relative Quantities of Petroleum Products Consumed By Motorists.

Product	Quantity, bbl
Gasoline	1000
Motor oil	12
Transmission and differential oils	2
Chassis greases	1

Gasoline of the trade is not a virgin petroleum stock but a blend of different materials which are obtained by a variety of manufacturing methods. The blends are adjusted so as to insure their best performance in the automobile.

Fuel is fed to an engine by means of pumps. Some of the pumps use suction while others operate under pressure in taking gasoline from the tank. If suction is employed and the gasoline contains a large proportion of very volatile materials, the pump will draw in the vapors instead of the liquid. As a result, the quantity of combustible materials reaching the carburetor, where gasoline is vaporized and mixed with air, is insufficient to provide an explosive mixture, and the engine will stall. Likewise, when an engine is hot, a similar condition, known as vapor-lock, may develop. Gasoline vaporizes rapidly in the fuel lines even with pressure feed, and the driver may experience difficulties in starting his car after the engine accidentally stops in traffic, for instance, at an intersection due to incorrect application of brakes. This limits the use of excessive volumes of light gasoline components in high-grade products.

However, if high-boiling materials are present in excessive quantities, the starting of a car is difficult and sometimes impossible. These compounds will not vaporize in the carburetor and mix with the intake air to form an explosive mixture. On the other hand, after the engine becomes hot, this difficulty is automatically eliminated and gasoline containing them may have the added advantage of giving a higher mileage per gallon of fuel burned. This happens because for equal volumes the heavy hydrocarbons release more energy on burning than the light hydrocarbons.

This leads to an interesting conclusion that a fuel required for good starting is not the same as that best suited for a hot engine. Passenger cars have one fuel tank, and the use of two kinds of fuel is practically impossible. Moreover, it would be a nuisance to the driver to remember from which tank he is drawing his fuel supply. Gasoline distributed by reliable oil concerns represents the best compromise between the two opposite requirements, and much experimental work is continually in progress to insure the motorist maximum return on his money.

The condition is different with commercial vehicles traveling over long distances, such as transcontinental trucks, where the cost of fuel is an appreciable item of the total operating expense. Savings are effected by employing two fuel tanks, one filled with gasoline and the other with heavy fuel, such as kerosine of satisfactory burning characteristics. The truck driver uses gasoline first until the engine is heated to the normal cruising temperature. At this moment, he switches fuels and continues to run on kerosine until he approaches the point of destination. Before stopping the engine, he again switches to gasoline in order to clear the lines of kerosine and to insure easy starting the next time. Unless he does this, he will certainly be disappointed trying to start his engine, particularly in cold weather.

We see advertisements about winter and summer grade gasolines. The above discussion discloses the differences between them. Gasoline sold in the summer contains more of the heavy components than gasoline sold in the winter. Starting is easy in summer, but the presence of large vol-

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umes of very low-boiling substances is liable to cause vapor lock. Summer gasolines have a slightly greater mileage than winter gasolines because of these differences in composition. Gasolines which contain larger quantities of low-boiling materials are said to possess a higher "volatility" than those which contain less of them.

Specifications require that gasoline boil within a definite temperature range. In addition, certain quantities of it must boil within the temperature limits also specified. This insures good starting of the motor, high mileage and freedom from vapor lock. The vapor pressure of a gasoline must not be excessive, to prevent vapor lock and high evaporation losses in storage.

What Makes an Engine Knock?

Another important property of gasoline is its anti-detonating or anti-knock quality. As has already been mentioned, gasoline is vaporized and mixed with air in the carburetor and the mixture is injected into the cylinders and ignited. The resulting explosion pushes the piston traveling within the cylinders, and this force is transmitted by a series of interconnected rods and gears to the wheels of the car.

The idea is simple, but the problem of preparing a satisfactory fuel is complicated. If the fuel-air mixture explodes all at once, the action is similar to that of an atomic bomb. The piston and other mechanical parts of the engine cannot absorb the shock effectively and may fail completely. The rapid rise in temperature may cause uneven expansion of metallic parts and result in "freezing" of cylinder heads and pistons, thus disabling the motor. At best, most of the energy present in the gasoline is lost and the engine becomes overheated. While the harm is done only to the engines, in automobiles, it frequently means disaster in airplanes. In both engines, however, gasoline should be used which does not detonate or knock. This knock — a sharp metallic sound — is familiar to automobile owners who try to climb a steep hill in high gear.

The piston in the engine cylinder has a definite, restricted path which it can travel. The volume of the space within the cylinder is fixed by the two extreme positions of the piston. The ratio between the two corresponding volumes is known as the "compression ratio." This is shown in Fig. 1. For instance, if the maximum space taken up by the gases after the expansion is six times that before the explosion, the compression ratio of the engine is 6:1. Compression ratio of modern automotive engines approaches 10:1, and may climb to 12:1 in the future. It cannot climb forever without a complete change in design for the reasons explained under diesel fuels. Compression ratio depends entirely on engine design. It has little to do with engine performance as far as the motoring public is concerned. The higher this ratio, the more likely a fuel is to knock.

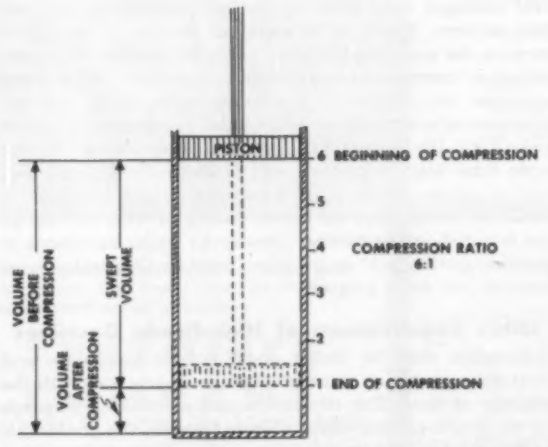


FIG. 1. Diagrammatic illustration of the meaning and method of calculating compression ratio in an internal combustion engine.

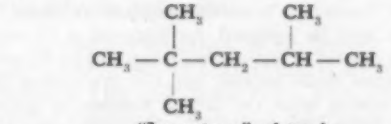
Experiments show that gasolines having identical boiling ranges and similar in many respects may differ widely in their knocking qualities. The latter were found to depend on the nature and shape of molecules of which gasoline is composed. Two hydrocarbons having the same number of hydrogen and carbon atoms in the molecule but combined in different ways will behave differently in an engine, i.e. the further the molecule deviates from the straight-chain design, the better are the anti-knock qualities of the hydrocarbon. The best structure is a circle, rather a sphere in our three-dimensional world. Typical examples of variations in the molecular structure are shown in Part III, June, 1955.

Detonation can be avoided by using engines having low compression ratios; however, high compression ratios decrease gasoline consumption on long distance drives, permit the use of lighter weight engines for the same power output, and have a few other advantages in special services.

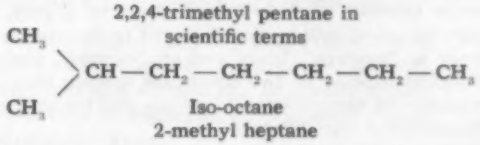
Nothing is gained by employing gasolines of high anti-knock qualities in low compression engines because the gasoline has no opportunity to exhibit its superior performance in comparison with other gasolines. The same applies to high compression motors if they are used in light service. The value of high compression engines as reflected in the pocketbook of their owners has still to be proven.

What Is Octane Number?

The anti-knock characteristics of gasoline are expressed in terms of "octane number." The octane number refers to standard mixtures of two pure chemical substances. One of these substances is iso-octane (this is a misnomer, because the hydrocarbon chosen for this standard is not iso-octane of the correct chemical nomenclature, but another isomer of octane, 2,2,4-dimethylpentane); the other is normal heptane. The structure of commercial iso-octane as compared to that of the true iso-octane is shown below:



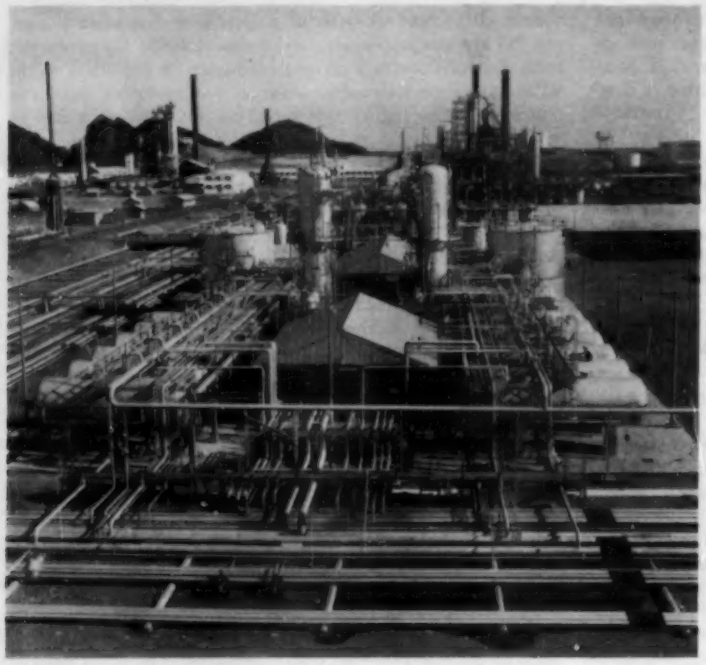
"Iso-octane" of trade
2,2,4-trimethyl pentane in
scientific terms



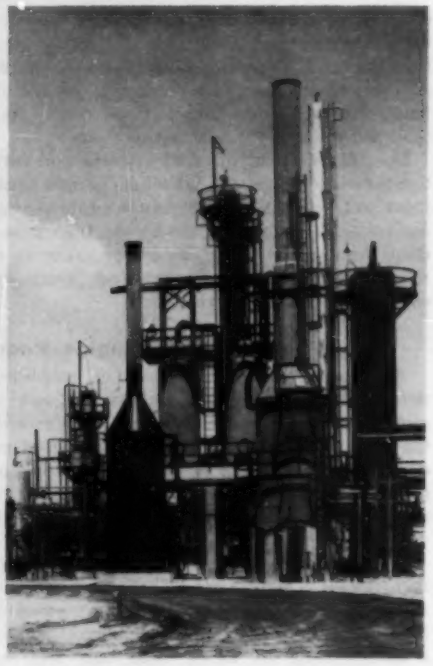
Iso-octane
2-methyl heptane

This is an illustration of how scientific terms are used by the trade without paying attention to their real significance. Commercial "iso-octane" is a much better fuel than the true iso-octane.

"Iso?octane," i.e. 2,2,4-dimethylpentane, has exceptionally good anti-knock characteristics and it was gained an octane number of 100. Normal heptane, on the contrary, detonates easily, and its octane number in the same arbitrary manner has been assumed to be 0. By mixing these two substances in all proportions, a series of fuels is obtained covering the whole scale of possible gasoline mixtures; this series is exact, and may be reproduced easily. It is, therefore, used as a standard with which various gasolines are compared. On this basis, an octane number



Complicated unit for "sweetening" gasoline. British Petroleum Company unit at Aden.



A catalytic conversion unit for production of improved motor fuels.

of 80, for instance, refers to a blend containing 80 per cent by volume of "iso-octane" and 20 per cent by volume of normal heptane. As has already been mentioned, the octane number is a very important property of gasoline and is, therefore, included in gasoline specifications. High grade gasolines now used in automobile engines have an octane rating close to that of pure iso-octane, that is, they approach the 100 mark.

The methods for evaluating the burning qualities of gasolines appear simple, but complications arise in practice. This is due to the fact that under different conditions of running, an engine may rate gasolines differently with respect to the "iso-octane"—normal heptane mixtures. The same gasoline may be assigned, for instance, a 70 octane number under one set of testing conditions and an 80 octane number or higher under another set. For this reason little is gained by asking what the octane number of gasoline is. Companies selling it within their marketing areas know what the motorist wants to keep him out of trouble. Expensive statistical information collected in the attempt to discover an "average" driver and an "average" road are meaningless because no two Americans operate their cars alike under the same driving conditions and the landscape of the country is also different.

Weather temperature, elevation, method of driving the car, driver's habits to drive up the steep hills have much more to do with the ease of driving than the official octane numbers, which happen to change according to the selection of the laboratory scale. Several methods can be used for measuring octane number, and all of them give different results. Motor, research, L-3, "road," and other octane scales can be used with full theoretical justification, except that all of them fail to agree among themselves on fuel evaluation. Rudolf Diesel (1858-1913) committed suicide trying to solve somewhat similar problems connected with his diesel engine. Problems connected with the development of the high compression engines are being solved less dramatically by methodical research of our petroleum and automotive companies.

Octane rating of motor gasoline shows a steady increase for many years. This is shown by the data presented in Table 3.

TABLE 3. Rise in Octane Number of an Average Motor Gasoline During the Last 25 Years.

Year	Octane Number of Gasoline	
	Regular	Special
1930	63	70
1935	75	82
1940	78	84
1945	75	80
1950	82	90
1955	88	95
1960	94 (?)	100 (?)

The decline in octane number of gasoline between 1941 and 1945 was caused by the diversion of high grade stocks for meeting the army demand during wartime.

Data presented in the table are national averages. Like all statistical information, their meaning is obscure. Statistical averages vary with the institutions making independent surveys. This is to be expected because of the differences in the sampling methods. Large fluctuations in octane ratings of commercial gasolines are observed even if these averages are compared. For instance, in 1955, average octane numbers of regular and special gasolines sold in Salt Lake City, Utah, were 81.6 and 90.1, respectively. At the same time, regular gasoline sold in Bakersfield, California, had an octane rating of 90.4 and special gasoline sold in Houston, Texas, had an octane rating of 96.9 on one of the selected octane-number (research) scale. Variations in gasoline quality sold in the same town by different service stations are even greater.

Other Requirements of High-Grade Gasolines

Gasoline must be stable under service conditions and in storage; that is, it must not change in any way with the passage of time. The desired degree of stability depends on the length of time which elapses between the production of the gasoline and its use in an engine. Unstable gasolines may deposit certain quantities of a semi-solid substance

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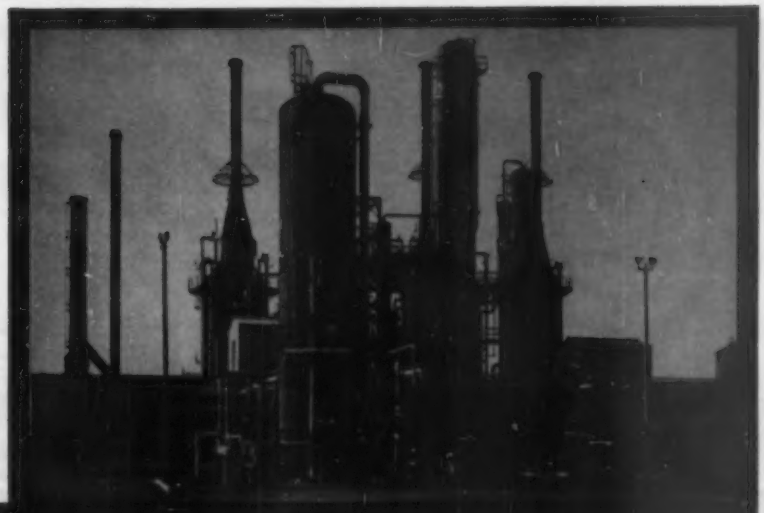
TO INSURE

smooth operations
more time on stream
lower operating costs
better products



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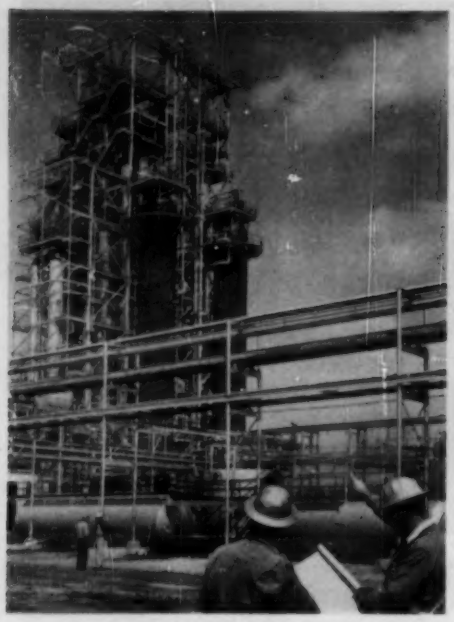
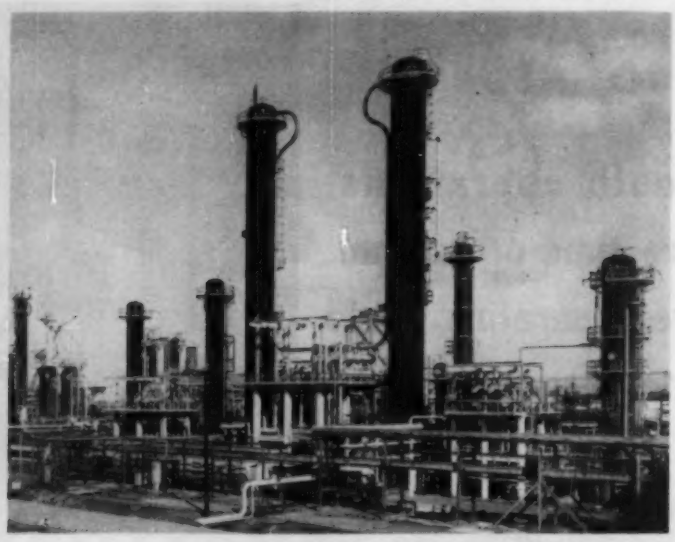


A large modern unit for production of motor fuel by catalytic cracking of heavier fractions.



In this (Phillips Petroleum Company) hydrofluoric acid alkylation unit, C_3's, C_4's, etc., are reacted to form alkylate, high-octane number component of aviation and "premium" motor fuel.

known as gum. It plugs the fuel lines and the carburetor and interferes with the free flow of fuel to the engine cylinders. The engine begins to sputter and the cylinders start missing. Only a very small quantity of gum is permissible in a gasoline if this condition is to be avoided. It is, therefore, important that the quantity of gum be kept as low as possible. Gasoline can be freed from gum by careful refining. This involves additional manufacturing cost.

Gum content of a gasoline has no relation to its octane number. For instance, the straight-run gasolines are very stable but their octane number is low. The gum content of gasoline is determined by carefully conducted laboratory tests. In these tests, a known volume of gasoline is vaporized under standardized conditions and the weight of residue is found by using sensitive analytical balances. The value of these tests is just as difficult to interpret as that of the tests involving the determination of the octane numbers. More detailed discussion of laboratory tests, their meaning, and interpretation will be given in the chapters devoted to these subjects.

The gasoline must be non-corrosive. If large quantities of sulfur compounds are present, they form on burning a pungent gas called sulfur dioxide. The odor of this gas is similar to that produced on striking a match, which contains a relatively large amount of sulfur. In the presence of water, the gas attacks iron and other metals, causing their corrosion. In the absence of water, the gas is harmless to equipment. In hot and damp climates, moisture condenses and carries sulfur dioxide with it. Then it does harm to metals. In cold weather, the effects are similar because moisture condenses much more easily with a few degrees change in temperature. Sulfur content, as the rest of gasoline tests, must be properly interpreted before significance can be attached to it.

Many tests are included in gasoline specifications. These tests may refer to the color or odor, to the quantities of unsaturated hydrocarbons present, to the so-called "doctor test," and to other properties. Few of them are of established practical value. For instance, color requirements have been repeatedly demonstrated to be superfluous because color of gasoline has no relation to its performance. Meeting test requirements for unsaturated hydrocarbons, such as acid heat or bromine number, is of the same questionable value, particularly because the degree of refining required to pass them may have an unfavorable effect on some of the more important properties. This happens because nearly all the unsaturated hydrocarbons found in gasolines are stable, particularly if they are protected with inhibitors, and they usually have good anti-knock characteristics. Rigid acid heat or bromine tests preclude their incorporation in gasoline.

Severity of the requirements varies with the type of gasoline. The most exacting specifications have been developed for gasolines employed in airplane engines, because failure of these engines during flight may result in a catastrophe. Aviation gasolines also differ from regular motor gasolines in having a lower and narrower boiling range to insure the best possible performance at high altitudes. Such gasolines must stay liquid at very low temperatures and pass the freezing test. Both aviation and motor gasolines are subdivided into a number of grades in order to satisfy climatic conditions and a variety of customers. Some customers are more interested in low price than in quality of product. They fail to see the connection between the quality of petroleum products they use and the bills they have to pay for mechanical repairs.

In order to meet the demand for the various gasolines, the refiner resorts to blending of numerous materials which he has on hand and which boil within the gasoline range. Such materials may arise from a number of sources and are produced directly from the crude oil or obtained in the course of its processing. These materials include straight-run gasoline, thermally and catalytically cracked gasolines, natural gasoline, semi-synthetic, or synthetic materials and chemicals. As the refinery operations are involved, production of gasoline is described together with the manufacture of the synthetic type of materials which are obtained from crude oil by processes other than straight distillation.

Gasoline Additives

Properties of gasoline can be improved by the use of

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additives. These additives are specific in their action. Several additives are used if more than one property of gasoline must be improved.

Anti-knock characteristics of motor fuels can be improved not only by the use of special petroleum fractions but also by adding very small quantities of chemicals which prevent detonation in the engine. Some years ago, an observation was made that the knock characteristics of gasolines were suppressed by adding a little iodine. This was impractical because the quantity and cost of iodine needed to obtain the necessary degree of improvment is large and iodine reacts chemically with the hydrocarbons. Standard Oil Company (New Jersey) used this clue in order to discover other substances which would be of greater promise. More than 3000 different chemicals were tested before tetraethyl lead was discovered. The late Thomas Midgley was largely responsible for the conduct of this brilliant piece of chemical research. The new gasoline was first put on the market in Dayton, Ohio, February 1, 1923, and since that time it has been universally used in this country and abroad. The "ethyl" gasoline is well known to motorists by its red color.

Tetraethyl lead is sold by the Ethyl Corporation and by the duPont de Nemours Company in the form of ethyl fluid which contains in addition to tetraethyl lead, some chlorine and bromine compounds and usually a red dye. Presence of these chlorine and bromine compounds is necessary to improve the volatility of lead and prevent formation of lead deposits in the engine. Demand for bromine for this product induced the Dow Chemical Company to set up a plant to extract it from sea water—a notable feat of chemical engineering. The dye is used to forewarn the public that highly poisonous tetraethyl lead is blended with the gasoline. According to the U.S. safety regulations, the maximum quantity of tetraethyl lead in motor gasoline must not exceed 3 cu cm per gallon or 0.08 per cent by volume. In exceptional cases, such as in preparing certain grades of aviation gasolines, this quantity may be raised to 4 to 6 cc per gallon. France used up to 12 cc per gallon during World War II.

Use of tetraethyl lead in very large amounts is of little benefit because its efficiency in improving the anti-knock properties of gasoline is not proportional to the quantity added, but falls off rapidly as the quantity increases. Moreover, if concentration of tetraethyl lead in the gasoline is high, formation of lead deposits may have an unfavorable effect, forcing the refiner to keep its consumption at a minimum level. In the "leaded" gasolines sold to the public, the quantity of tetraethyl lead approaches infrequently the upper legal limit of 3cc.

One of the surveys conducted in 1955 showed that the tetraethyl lead content of regular gasolines varied between 1.10 and 2.55 cu cm per gallon and of special gasolines between 1.12 and 2.82 cu cm per gallon. A few excellent gasolines contained no tetraethyl lead, but they were exceptions.

As was already mentioned, tetraethyl lead is very poisonous, but it can be used in cars without danger to health because of the very small concentrations employed. However, even in these concentrations, it may become dangerous if the leaded gasoline is in close contact with the human body for a considerable length of time. It cannot be used for dry cleaning and similar applications.

No satisfactory substitute for tetraethyl lead has yet been discovered. Iron carbonyl has been tried for a number of years, then nickel carbonyl was investigated, particularly in Germany, but difficulties in handling these substances in engines resulted in the abandonment of such attempts. Tetraethyl lead should, therefore, be regarded as the only known practical compound of this type as yet discovered.

Stability of gasoline in storage can be improved by the use of additives known as "oxidation inhibitors." The action of these inhibitors is not always alike. For instance, one inhibitor, like alpha-napthol, may retard formation of gum but accelerate formation of color. Another inhibitor, like hydroquinone, may be particularly effective in protecting the gasoline color, if this is important. Different gasolines may require different inhibitors for maximum protection.

The quantity of inhibitors is often critical. Excess may be more harmful than deficiency. Instead of stopping an oxidation reaction, the inhibitor used in lavish amounts may promote it and thus become an "accelerator." For instance, elemental sulfur is an oxidation inhibitor if used in minute quantities. However, it speeds up oxidation and has a detrimental effect on gasoline properties after the maximum concentration is passed. This optimum concentration varies with the nature of gasoline and inhibitor.

A compound of phosphorus, like TCP (Tri-Cresyl-Phosphate) may be added to retard deterioration of spark plugs and carbon formation in the cylinders. Isopropyl alcohol and other substances are used to prevent the minute quantities of water dissolved in gasoline from precipitating in cold weather and forming ice particles, which may stop the flow of gasoline. Additives known as metal deactivators, are helpful for removing from gasoline traces of copper and other metals which are harmful to gasoline stability. Corrosion inhibitors are also employed. This shows that much experimental work is required before a satisfactory formula is developed for the preparation of even such apparently simple products as gasoline.

Accelerated Testing

Gasoline, as well as other materials manufactured by a refinery, must be tested before being released to the market. Experimental work required for the improvement of old and devlopment of new products demands a large amount of testing. Such tests must be completed in a reasonable length of time. Besides, if a product is tested by allowing it to deteriorate in storage, no satisfactory materials would ever reach the customer. This necessitates the use of accelerated tests.

In these tests, reactions are speeded up by raising the temperature, increasing concentration of oxygen in the atmosphere surrounding the sample, bringing the oil in contact with large quantities of metals which promote formation of color and gum, and by other artificial means. In developing these tests, an assumption is made that chemical reactions leading to the deterioration or "aging" of an oil quicken their pace proportionately. This assumption does not stand a scientific scrutiny.

Reactions taking place under one set of conditions do not necessarily occur when the conditions change. Likewise, an increase in testing severity does not mean a parallel response from all the complicated reactions encountered in aging an oil. This can be illustrated by the examples taken from everyday life.

An increase in temperature is a common method used in accelerated tests for estimating stability of oils in long-time storage at normal temperatures. If such simplification were possible, it should be applicable for estimating the length of time a basket of eggs can be stored in a cellar without deterioration. However, if we expose an egg for a few minutes to the temperature of boiling water, its smell, taste, and appearance will have nothing in common with those of an egg slowly rotting on a shelf. This demonstrates that the very nature of the reactions changes with the change in temperature. The same applies to other quasi-scientific methods of speeding up the reactions artificially.

Accelerated tests are particularly unreliable when they are applied to oils protected from deterioration with inhibitors. Many reactions do not take place unless small quantities of "accelerators" or "promoters" are present.

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Research is working to make petroleum products better

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Yet, right from the start, most everything that is done in petroleum research concentrates on the development of improved products from petroleum, products better fitted to answer the demand of today's economy, products that fill as well as anticipate the growing public need.

Research, too, is devoted to the task of helping the refining industry get the most out of every barrel of crude that is processed in its plants. This makes possible the economical manufacture of petroleum products and their availability to the broadest markets at reasonable prices.

We have a lot of these men of science here at Universal, and there are lots more on the research staffs of refiners everywhere. It is good to know that their efforts are concentrated on the continual improvement of petroleum products, a satisfying assurance that the oil industry will continue to fulfill its responsibilities.

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30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U.S.A.

These accelerators have a chemical action opposite to that of the inhibitors. Inhibitors attack the accelerators and destroy them, thus stopping the progress of the undesirable chemical reactions at the very start. However, accelerators can destroy the inhibitors also.

An example from our everyday life can be used for visualizing the effects of inhibitors and accelerators. Milk becomes sour on account of microscopic organisms, known as bacteria, which multiply rapidly under favorable conditions. One of these conditions is the presence of a small quantity of acid. These bacteria do not grow in the presence of caustic. If a small quantity of caustic, like sodium bicarbonate, is added to the fresh milk, it will destroy the acid as soon as the acid is formed. Caustic will thus preserve the milk for several days in warm weather. The action of the caustic on the milk can be compared with that of an inhibitor. The inhibitors are effective only if they are sufficiently reactive to attack the accelerators and to exterminate them.

Reactivity of the inhibitors, like that of other chemical substances, changes with temperature. At low temperatures, the inhibitors are inert, at high temperatures they decompose. Each inhibitor has a certain temperature range within which it can protect the oil from deterioration. The accelerators have their own temperature ranges within which they are active. These ranges do not necessarily coincide with those of the inhibitors. An inhibitor may lose its activity or be destroyed by the action of temperature, oxygen concentration, and other artificial means used for aging an oil, while accelerators may continue to be active. As a result, a gasoline which is very stable in service may fail in the accelerated tests that a poor product may pass.

Quality of a new product can be established only after testing it under service conditions. This is lengthy and expensive but cannot be avoided. Then an approximate correlation is found between some accelerated test and service performance. This test can be applied for controlling the quality of the plant output as long as the processing conditions remain reasonably constant.

Gasoline Substitutes

The question arises whether fuels other than petroleum can be used in engines. The answer is "yes," but such substitutes are expensive. Alcohol is one of such fuels which finds from time to time its advocates in this country and which must be used in gasolines sold in some parts of Europe. This is done in order to assist the farmers in the disposal of surplus crops, like wheat or potatoes, which can be used for manufacturing alcohol. It is of interest that alcohol can be made cheaper from petroleum than from the farm products. For this reason, alcohol produced from petroleum is not allowed in beverages as this would reduce the farm income even if this alcohol is purer in composition and is a healthier drink than the alcohol obtained by fermentation and containing fusel oil. (Higher alcohols.)

For equal quantities, alcohol contains considerably less heat than gasoline. On burning one pound of alcohol, 11,620 Btu of heat are released as compared to 20,750 Btu obtained from one pound of gasoline. Alcohol is 7 per cent heavier than an average gasoline, and this correction must be applied by changing from weights to volumes, i.e. to the basis on which the motor fuels are sold. By making these corrections, it will be found that 7 quarts of alcohol are needed to produce the quantity of heat or power stored in 4 quarts of gasoline.

Cost of gasoline at the refinery was about 11 cents per gallon in 1955. If alcohol is sold in competition with gasoline, its price must be reduced to 6.3 cents per gallon as compared to its present price of over 20 cents per gallon in bulk quantities. In addition, if alcohol is used as a gasoline substitute, the service stations and the motorists would have to handle much larger volumes of fuel for the cars covering the same distance. If these costs and taxes based on volume and not on product quality are taken into account, the price of motor fuels will rise from its present 29 cents average to more than 50 cents.

Alcohol has another disadvantage when compared to gasoline; it dissolves water. Alcohol diluted with water loses much of its value as fuel because heat is consumed in vaporizing the water. This heat must be supplied by the alcohol, reducing the power output of the alcohol even further. If alcohol-gasoline mixtures are used, they separate into two layers when their water content becomes higher than the saturation point. Water is likely to get into the gasoline tank, particularly in damp climates. Alcohol is extracted from gasoline by water and must be discarded when the water layer containing it is drained from the tank.

The only advantage alcohol has over most of the gasoline hydrocarbons is its high octane number, which is about 99 or close to that of isooctane. However, new catalytic processes produce gasolines having octane numbers over 100 at a reasonable manufacturing cost. They are cheaper to make than alcohol. Addition of minute quantities of tetraethyl lead increases markedly the octane number of all gasolines.

In concluding this discussion, it might be mentioned that gasolines obtained from different crude oils vary widely in their characteristics. For instance, Pennsylvania crude oils yield gasoline of poor antidetonating properties. Coastal and asphalt-base crude oils yield high quality gasoline, and the mixed-base or Mid-Continent crude oils yield gasoline of intermediate quality. Although the octane number of gasolines from the asphalt-base crude oils is sometimes exceptionally high, it is lower than that obtained by modern refining processes from any crude oil.

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REFINING IN BRIEF

Stopping Sulfur Corrosion In a Catalytic Reformer

B. W. Neumaier[1] *Richfield Oil Corporation* and C. M. Schillmoller[2] *International Nickel Company*

CATALYTIC reforming is the refining process tool which is presently playing the major role in the diversification of manufacturing operations. It provides a method for making high-octane gasoline, aromatics, and by-product hydrogen. The importance of the process is emphasized by its very rapid acceptance and growth.

This process operates at high temperature and high hydrogen partial pressure in the presence of a catalyst. Most of the sulfur compounds in the feedstock form hydrogen sulfide under these conditions. Evidence has appeared of unexpected high corrosion rates in commercial catalytic-reformer units, as a result of hydrogen sulfide, in the presence of hydrogen at temperatures of 700F to 950F and pressures over 200 psi. The sulfide corrosion phenomenon seemed entirely different from sulfide corrosion in thermal- and catalytic-cracking units. The low-chrome steels, which had been found resistant in these media, were found not much more resistant than carbon steel to this new type of high-temperature corrosion. Consequently, the alloy selection for the first reformers, based on conventional economic practices, was found inadequate.

[1]Richfield Oil Corporation, Wilmington, California.
[2]The International Nickel Company, Inc., Los Angeles, California, formerly with Richfield Oil Corporation.
*Condensed by the authors from a paper presented to a session on corrosion during the twenty-first midyear meeting of the American Petroleum Institute's Division of Refining, Montreal, Quebec, Canada, May 14, 1956.

Richfield Oil Corporation is making an all-out effort to avoid the very high corrosion rates and the scaling problems which are caused by high-temperature sulfide attack in catalytic reforming and associated processes.

Anticipated maximum corrosion rates have been plotted for different hydrogen-sulfide concentrations at temperatures which occur in reformer and hydrodesulfurizer units. Metallurgical selection was based on these graphs.

The importance of applying corrosion control in the design stage of a unit is stressed. It is far more economical to prevent corrosion before it becomes a problem, by building resistance into a structure, than it is to attempt to stop corrosion after it has taken its partial toll.

Analysis of Problem

Hydrogen-sulfide attack: When hydrogen sulfide attacks steel, it combines with the iron and forms an iron corrosion-scale layer. The rate of corrosion depends on the hydrogen sulfide concentration and on the temperature. Initially, corrosion proceeds very rapidly and, as the scale thickness builds up, the rate of corrosion diminishes. There are *two mechanisms* involved shown in Fig. 1: adsorption of hydrogen sulfide at the corroding surface, and, diffusion of ferrous ions outward and sulfide ions inward. The ferrous ions are believed to control the diffusion and corrosion rates. If the scale could build up to a dense and stable sulfide scale like it does in thermal and catalytic-cracking sulfide corrosion, then corrosion would proceed at an acceptable low level. However, that is not the case when a high partial pressure of *hydrogen is present*, because of its high chemical activity.

Looking at the corrosion reaction, one would expect the reaction to reverse in the presence of excess hydrogen and this would slow the corrosion down. This would indeed be the case if its effect were not overshadowed by a *secondary reaction*, in which hydrogen reacts with the ferrous sulfide scale. The hydrogen reduces the scale, and by extracting sulfides from the scale, makes the scale more permeable, with an open lattice, through which the ferrous and sulfide ions can maintain high diffusion rates. This makes the scale brittle, crumbly and not very adherent. The scale readily flakes off when the temperature fluctuates or because of oxidation. Also, the hydrogen minimizes carbon deposition, and the absence of carbon helps to keep the scale porous.

Hydrogen attack: We are familiar with high-temperature hydrogen attack in ammonia plants and in other hydrogenation processes. Damage in these plants has occurred as decarburization and intergranular cracking. Fig. 2 shows part of a well known graph developed by George A. Nelson,[1] on which the *safe operating limits* for carbon steel and low-alloy steels are defined. Chromium and molybdenum have a stabilizing effect on carbon steel and prevent the combination of hydrogen with carbon.

The purpose of showing Fig. 2 is not only to establish the minimum alloy requirements for the reformer and desulfurizer, but more to point out the *curvature of the carbon steel line*. Note the quite sudden and very rapid de-

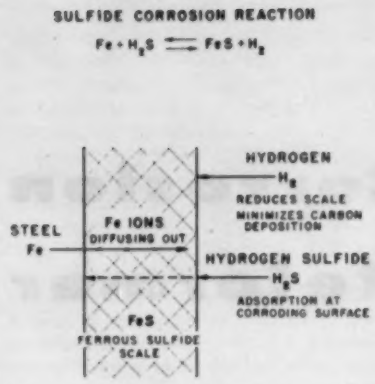


FIG. 1. The hydrogen sulfide corrosion reaction at high temperature.

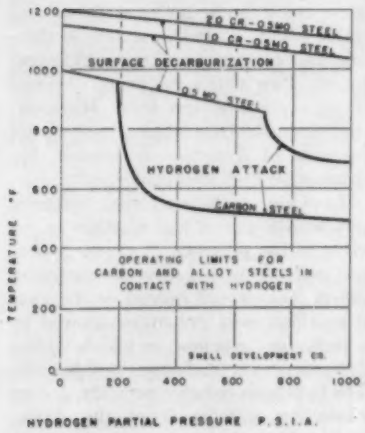


FIG. 2. Operating limits for carbon and alloy steels in contact with hydrogen.

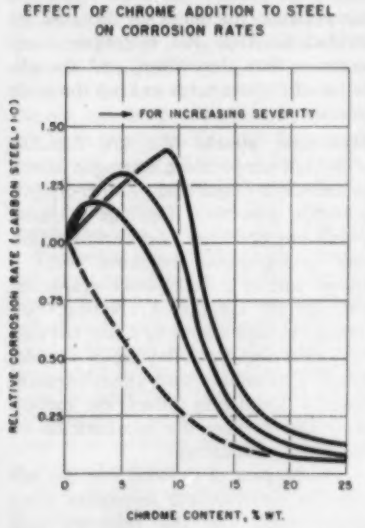


FIG. 3. The effect, on sulfur corrosion rates, of the addition of chromium to steel.

crease in resistance of carbon steel to decarburization at a hydrogen partial pressure of about 200 psi. Above 200 psi partial pressure hydrogen is very reactive. The reactivity does not seem to increase much when partial pressures are raised from 400 to 1000 psi, or for that matter to 10,000 psi. This is interpreted as one of the reasons why little effect of pressure is noted on the sulfide reaction when operating over 200 psi partial pressure of hydrogen. And that is why, as shown later, the anticipated corrosion rate graphs are plotted against hydrogen sulfide concentrations, rather than hydrogen sulfide partial pressure.

Effect of chrome addition to steel: On Fig. 3, corrosion rates are plotted for chrome steels relative to carbon steel, carbon steel being one. The effect of chrome addition to steel on sulfide corrosion rates should be noted.

At the lower pressure occurring in thermal and catalytic cracking processes, the corrosion of steel by hydrogen sulfide decreases with increasing chromium content. This is indicated by the dotted line. The chrome-steels, heretofore considered effective in resisting sulfur attack at elevated temperatures, offer no improvement over plain carbon steel when *under pressure* in the presence of hydrogen as indicated by the solid lines. Dittrich's work[2] showed that low chrome-steels up to 10 per cent chromium are more vigorously attacked than carbon steel. Maxima have been found for 2¼ chrome, 5 chrome and 9 chrome-steels for increasing severity of sulfide attack. As can be seen the 12 chrome steels offer an improvement anywhere between 20 and 60 per cent, but their performance is hard to predict since it falls on the steep part of the curve. The 18 per cent chrome-steels, with 8 per cent nickel added, have consistently given low corrosion rates.

Scale stability: Corrosion rates diminish with scale thickness. Often several layers of scale can be noted, the number of which is said to correspond to interruptions in operations. Each layer corresponds to a major change in temperature or in hydrogen-sulfide concentration. The outer layer is brittle and easily flakes off.

Scale stability is a desired feature in reducing corrosion rates. Once a dense iron-sulfide scale is established, continuous corrosion proceeds at a low rate. In operation, scales can be jarred loose by mechanical means; or by rapid temperature changes resulting from the difference in thermal expansion of the scale and the metal; or by oxidation, which causes the scale to shrink and spall off.

Removal of the protective sulfide scale exposes bare metal to the returning sulfide reactions. This results in a periodic returning of the steel to high initial corrosion rates.

Loose scales interfere with the operation of the unit. The scale thickness is generally 3 to 4 times as much as the thickness of metal loss. In some instances these scales have plugged equipment, causing high pressure drops across the reactors; they have also fouled heat exchangers and the heater tubes of furnaces, causing poor rates of heat transfer. Some companies report catalyst poisoning by iron sulfide.

Description of Richfield's Units

Richfield Oil Corporation's catalytic-reforming unit was process-designed by Sinclair Research Laboratories, and uses Sinclair-Baker catalyst. Charge capacity is 17,000 bbl per day. It is located in the Watson Refinery at Wilmington, California, and went on stream in June, 1956. Nature of the reformer feedstock, which consists of straight-run naphtha and viscosity-breaker naphtha, is such that pretreating in a hydrodesulfurization unit is required. This pretreatment saturates olefins in the cracked components of the feed and removes sulfur, nitrogen, and other reformer-catalyst contaminants. Descriptions of the reformer and desulfurizer processes are shown in Fig. 4 and 5.

Operating conditions: In order to accomplish the desired reactions in these units, elevated temperatures and high hydrogen partial pressures are necessary. The reformer-reactor inlet temperatures will range between 900 F and 975 F, depending upon the catalyst activity and the reformate octane desired. The desulfurizer-reactor temperature will be approximately 780 F. In both processes a high partial pressure of hydrogen is required. This is accomplished at moderate pressures by employing a high recycle-gas ratio, which increases the hydrogen concentration.

Steps to Minimize High-Temperature Sulfide Corrosion

We have seen that the conditions of high temperature and high hydrogen partial pressures are fixed by operation and that, under these conditions, hydrogen sulfide, formed from the sulfur compounds in the feedstock, is very reactive and rapidly attacks low-chrome steels.

The key question to which an answer was sought was "What are the maximum corrosion rates we can anticipate in catalytic-reforming and hydrodesulfurizing equipment for different materials of construction?" Rates of corrosion, as affected by material and hydro-

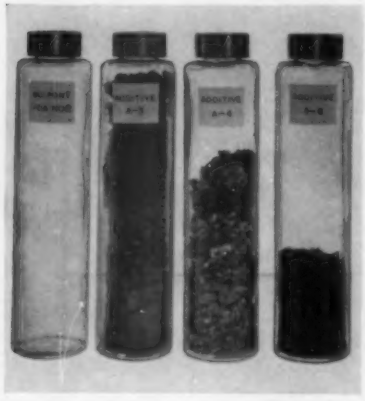
PETROLEUM CHEMICALS DIVISION
NEWS

December ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

You can SEE the advantage of using ASHLESS Du Pont FOA-2

When you burn 1,000 gallons of home heating oil containing a dispersant additive, how much ash does the additive leave?

That depends on the additive—as the picture below clearly shows.



These bottles (8 fluid-ounce size) contain the amount of ash left from burning four different heating oil additives.

The bottle on the left contains practically *no* ash, although enough *non-metallic* Du Pont Fuel Oil Additive No. 2 (FOA-2) was burned to protect 1,000 gallons of fuel oil. (Actual concentration: 20 lbs./1,000 bbls.) The other bottles contain the ash left after burning cost-equivalent amounts of three metallic additives. The difference is so striking that comment seems superfluous.

Stack control failures

What damage do these ash deposits do in the burner system?

Many stack control failures can be attributed to metallic ash deposits on the helical coil. And such failures are likely to prove hazardous and result in needless, unprofitable service calls.

In rotary burners, metallic additives leave deposits on the flame rim and electrode. These tend to short out the electrode, causing ignition difficulties. And even if ignition is accomplished, the deposits on the rim will interfere with the progress of the flame around it.

In diesel fuels

When metallic additives are used to stabilize economy grade diesel fuels, there is a danger that these additives will contribute a sparking tendency to the fuel.

* * *

For more information about FOA-2, just address your request to our nearest sales office.

New dry-dye drumhead makes eduction faster and cleaner

Du Pont petroleum dyes are now being shipped in drums covered with newly designed steel drumheads, each having a 2-inch circular opening. Through this the dry-dye eduction probe can be easily inserted and manipulated.

NOTE HOW easily the dry-dye eduction probe can be inserted through the opening of this new-type Du Pont dye drumhead.

This opening is sealed with a plastic disc. When the dye is to be removed, the disc can be easily cut out with a penknife. (See cut on next page.)

The opening is rimmed with plastic which is threaded to accommodate a standard 2-inch pipe plug. That means easy re-sealing . . . to protect the quality which is built into all Du Pont dyes.

The new drumhead need not be removed. Using the small opening instead reduces dusting to an absolute minimum. When the eduction probe is inserted, little open space is left around it. Hence little, if any, dry dye will

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OVER

DU PONT

PETROLEUM CHEMICALS DIVISION
NEWS

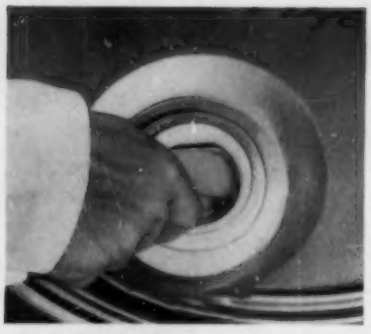
DU PONT

CONTINUED **New dye drum**

emerge, except as desired—through the probe itself.

Second recent improvement

The new drumhead follows by only six months another radical improvement in dry-dye eduction procedure—the new probe that is virtually clog-proof. More than 100 are now in service, and the demand for them continues.



FOR SHIPPING, the small opening is sealed with a plastic disc which can be easily cut out with a pocket knife.

Any of our sales offices listed below will be glad to give you complete information on the new dye drums and eduction probe. If you are not now using the dry-dye eduction system, our Operations Group will be glad to help you set up the complete installation.

A STANDARD 2-inch pipe plug keeps the dye drum tightly closed once the seal has been broken.

ASSISTANT MANAGER OF OPERATIONS

RUSSELL B. DAVIS has been attached to the Operations Group of the Du Pont Petroleum Chemicals Division since 1947. He currently supervises the work of this group, whose chief concern is to help refiners maintain safe, efficient handling of tetraethyl lead and other additives.

His contributions to safer TEL handling and more efficient plant operations in connection with the use of additives have been many. He played an important part in the development of such Du Pont-designed equipment as the metal-flex unloading hose, the siphon starter and the new, non-clogging dry-dye eduction probe.

After joining the Du Pont Company in 1933, his first assignment was in the Rayon Department. He was later transferred to the Engineering Department. From 1936 to 1947, he held a number of manufacturing positions in the Organic Chemicals Department, mostly connected with TEL manufacture.

Mr. Davis received his Mechanical Engineering degree from Rensselaer Polytechnic Institute. He is a member of the American Petroleum Institute, the National Safety Council and Sigma Xi Fraternity.

NEW DYE BOOK AVAILABLE
Gives detailed information on coloring all types of petroleum products

With the public becoming more and more color-conscious every day, refiners and marketers are putting increased emphasis on coloring all types of petroleum products.

Gasolines have been dyed for many years to indicate TEL content—also for brand identification. However, only recently have brilliantly hued greases, lubricating and home heating oils, kerosines and diesel fuels begun to appear. The merchandising advantages of using eye-appealing color for brand identification are no doubt an important reason for this trend.

To help refiners use petroleum dyes as effectively and economically as possible, we have just published a new manual on coloring petroleum products. All the latest methods of addition—including dry-dye eduction—are covered in this 20-page book.

It also contains data on meeting color requirements for military, aviation and leaded motor fuels. And full information on Du Pont Petroleum Dyes—with solubility charts and spectrophotometer curves—is included.

Just address your request for this book to one of our Petroleum Chemicals Division sales offices. Ask for a copy of "Du Pont Petroleum Dyes."

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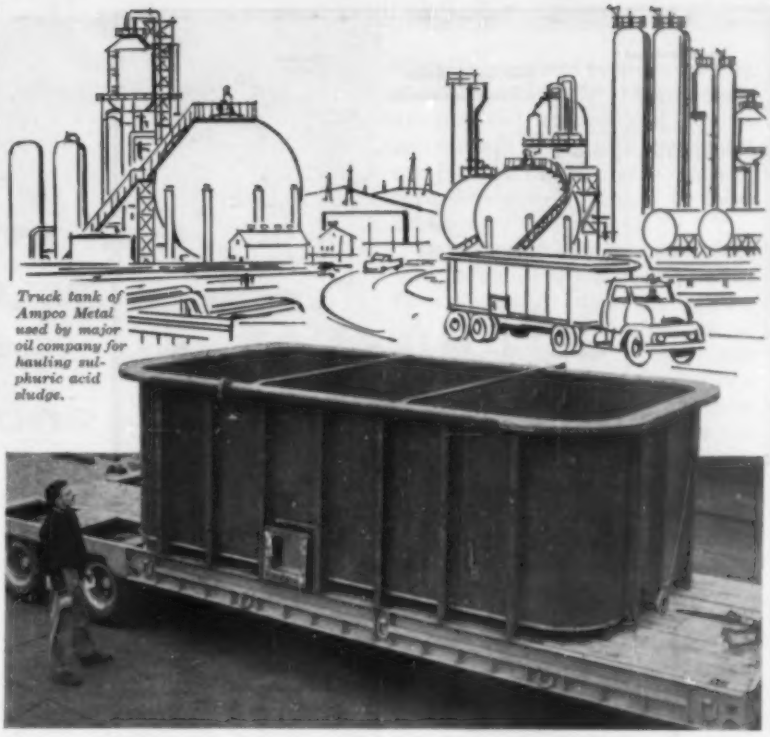
gen-sulfide concentration, were plotted for the average reformer-reactor and desulfurizer-reactor temperatures. Such corrosion-rate curves were developed from the best information which could be obtained from private contacts with other refineries who had, under way, projects connected with this corrosion problem.

Materials of construction were grouped in three categories with increasing corrosion resistance: carbon steel and low-chrome steels, the 12-per cent chrome steels, and the 18-8 chrome-nickel alloys. No significant difference in corrosion rates was found for the group of 0- to 9-per-cent chrome steels; they exhibited the poorest corrosion resistance. The intermediate group of 12-per cent chrome steels exhibited under mild conditions, i.e., at moderate temperatures and low hydrogen-sulfide content, corrosion rates which were approximately 50 to 65 per cent of those experienced with low-chrome steels. Under severe conditions corrosion rates of this intermediate group have been found as high as for the low-chrome steels. The 18-8 chrome-nickel alloys have consistently provided the best corrosion resistance. Corrosion rates were found to increase very rapidly with hydrogen-sulfide concentrations in the range from 0.01 to 0.10 per cent by volume. At 1.0 per cent by volume the rate is approximately double what it is at 0.1 per cent by volume. Relatively little increase is found in the range from 1.0 to 10.0 per cent by volume. Because of this almost parabolic relation between hydrogen-sulfide concentrations and corrosion rates, it was natural to plot the hydrogen-sulfide concentrations on a logarithmic scale. Fig. 6 and 7 give the graphs showing the anticipated maximum corrosion rates in catalytic-reforming and in hydrodesulfurization equipment, respectively.

Hydrogen-sulfide removal: The corrosion-rate curves leave no doubt that the solution to the high-corrosion problem lies in either employing 18-8 chrome-nickel alloys or reducing the hydrogen-sulfide concentration to a very low level. The quantity of sulfur in the feedstock and the recycle-gas ratio fix the hydrogen-sulfide content in the recycle gas and, thereby, the hydrogen-sulfide concentration in the whole high-temperature system. Because of the high recycle ratios generally employed, even a low sulfur concentration in the feed can create high hydrogen-sulfide concentrations in the system. Amine scrubbing of the recycle gas for hydrogen-sulfide removal eliminates the major influence of the recycle ratio, and a marked improvement in corrosion rates can be obtained.



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Handles 35% Solution of Hot Sulphuric Acid Sludge

Truck tank...made from Ampco Metal Grade 8 plate...resists corrosion

Ampco Metal resists corrosion, erosion, and cavitation-pitting caused by...

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Ampco Metal has exceptional resistance to the destructive attack of many alkaline and acid media.

That's one reason why this aluminum-bronze alloy is used in fabrications like the truck tank shown here; in pipe, fittings, and other forms.

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(3) It possesses high impact and fatigue strength.

You can get Ampco Metal in sheet, plate, extrusions, sand and centrifugal castings, pipe fittings, fasteners, tubing, pumps, valves, etc.

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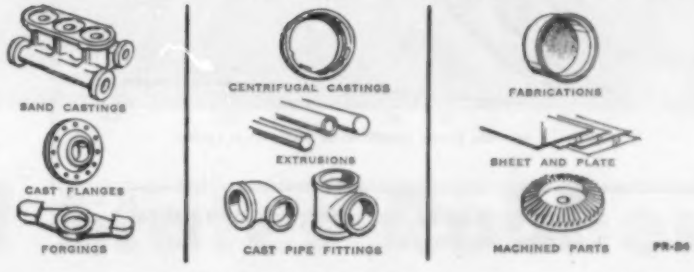

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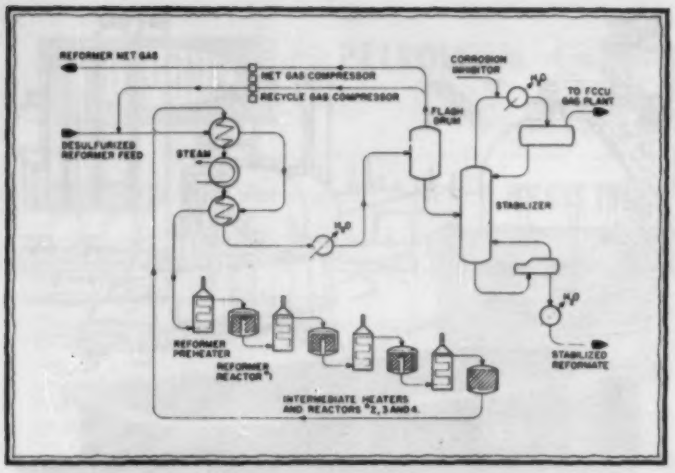

FIG. 4. Simplified flow diagram of a catalytic reformer.

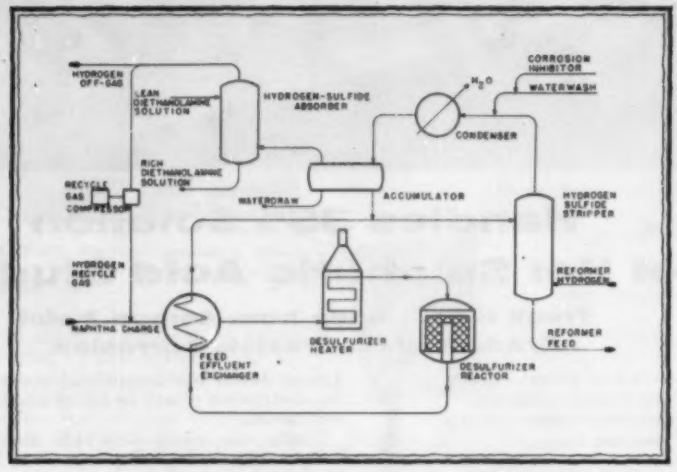

FIG. 5. Simplified flow diagram of a hydrodesulfurizer.

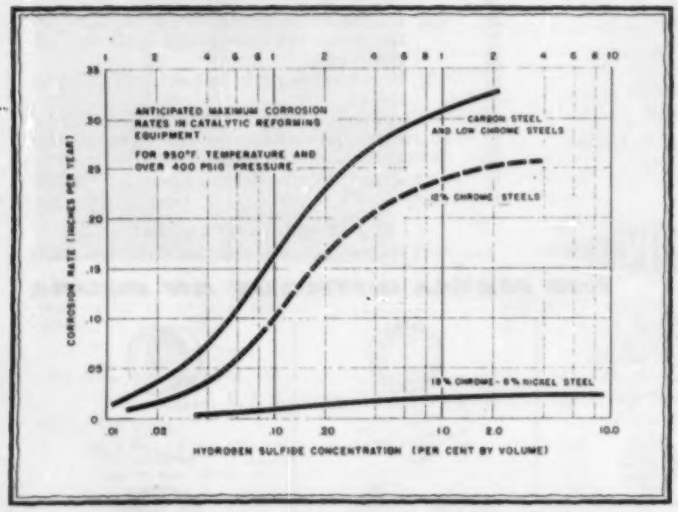
ANTICIPATED MAXIMUM CORROSION RATES IN CATALYTIC REFORMING EQUIPMENT
FOR 950°F TEMPERATURE AND OVER 400 PSIG PRESSURE
CARBON STEEL AND LOW CHROME STEELS
5% CHROME STEELS
18% CHROME - 8% NICKEL STEEL
CORROSION RATE (INCHES PER YEAR)
HYDROGEN SULFIDE CONCENTRATION (PER CENT BY VOLUME)

FIG. 6. Anticipated maximum corrosion rates in catalytic reforming equipment.

Basis of metallurgy selection: Metallurgy was selected on the basis of a maximum allowable corrosion rate of 0.05 in. per year for vessels, furnace tubes, and transfer lines, and of 0.03 in. per year for heat-exchanger tubes. We realize that, even at these rates, a considerable amount of corrosion scaling can take place. In the radial-flow reactors, allowance was made for scale collection and no high-pressure drops across the reactor beds are anticipated.

Reformer metallurgy: Hydrodesulfurization of the reformer feedstock reduces the sulfur content in the naphtha from 0.35 to below 0.01 per cent by weight. For this low-sulfur feedstock the hydrogen-sulfide concentration in the reformer system will approximate 0.015 per cent by volume. Fig. 6 indicates that, for this concentration of hydrogen sulfide, low-chrome alloys can be used safely. The chrome level is dictated by the required resistance to hydrogen attack (see Fig. 2). Because of its better mechanical properties, higher strength, and better carburization resistance, 1½ chrome-½ molybdenum steel was preferred above, say 5 chrome-½ molybdenum steel for vessels, heat exchangers, and transfer lines. For the heater tubes, 2¼ chrome-1 molybdenum steel was selected. The reactor vessels are made from carbon steel and are lined internally with an insulating refractory so as to maintain shell temperatures below the level at which hydrogen attack might occur. The internals of the reactors are made of 18-8 chrome-nickel alloy, type 347. Carbon steel is used throughout below 500 F. The metallurgy is shown in Fig. 8. The selection is fairly well established by practice and is comparable to many low-sulfur-feed reformers.

Amine scrubbing of desulfurizer recycle gas: Actually, by hydrodesulfurization of the reformer feedstock the severe corrosion problem in the reformer at 950 F is replaced by a milder one in the desulfurizer at 780 F. The same environment exists, but because of the lower temperature, corrosion rates are approximately 60 per cent less. The sulfur content in the combined straight-run naphtha and viscosity-breaker naphtha feedstock to the desulfurizer is expected to be approximately 0.35 per cent by weight. This would bring the hydrogen-sulfide content in the hydrogen recycle stream to approximately 0.78 per cent by volume. Fig. 7 indicates that this concentration, even at 710 F, can cause corrosion rates in the heater tubes as high as 0.10 in. per year unless high-chrome or stainless steels are employed. Corrosion rates in the reactor-effluent transfer line

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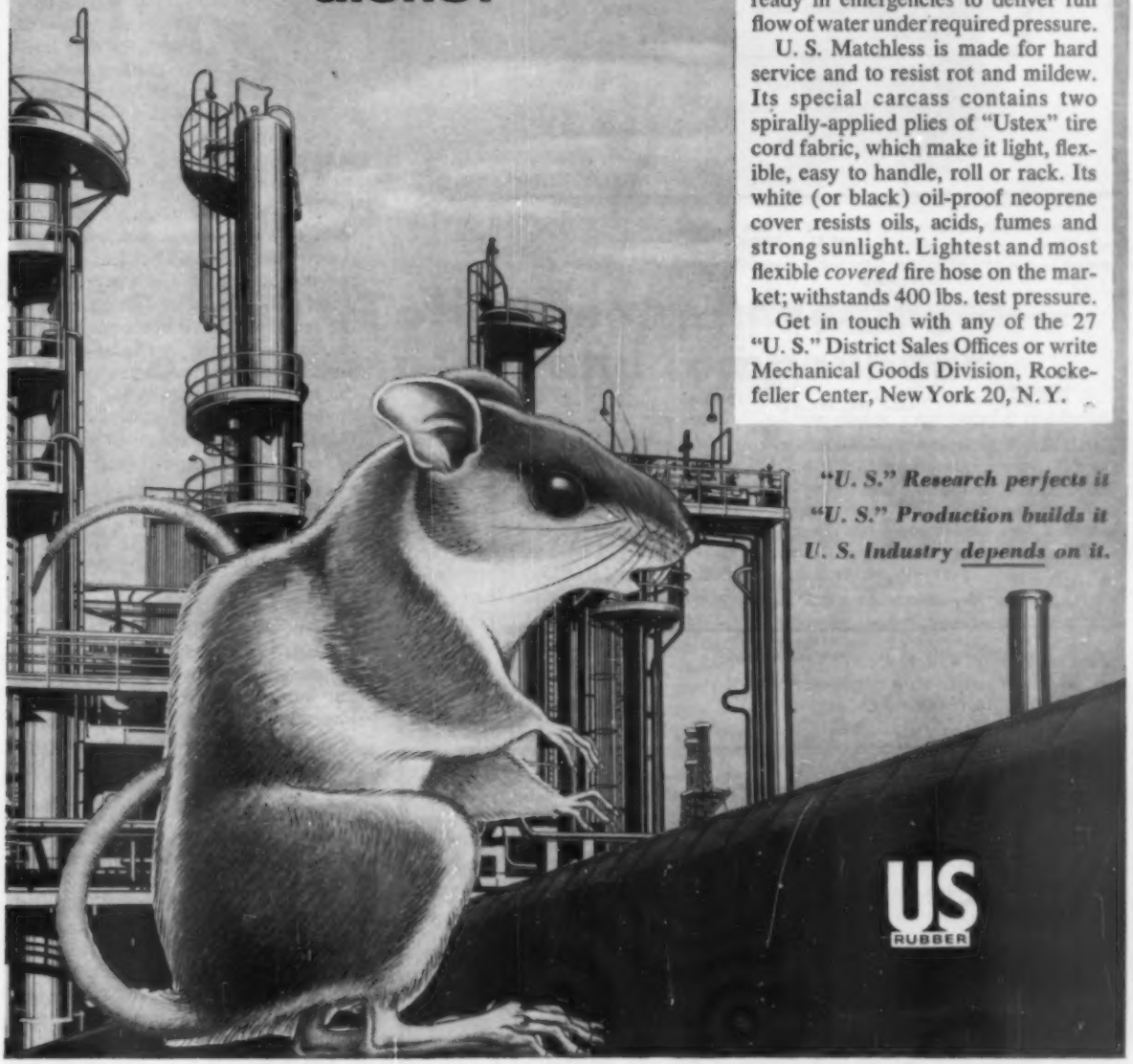

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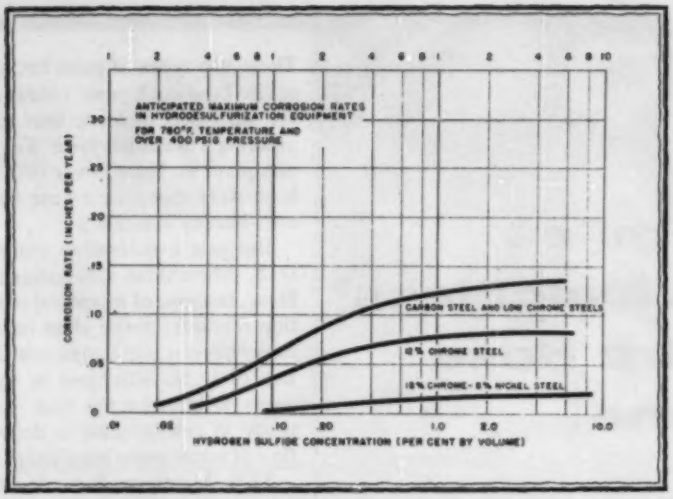
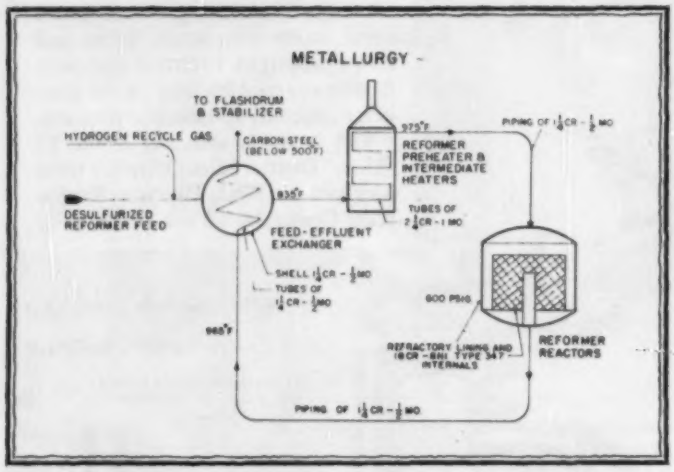

ANTICIPATED MAXIMUM CORROSION RATES IN HYDRODESULFURIZATION EQUIPMENT FOR 750°F TEMPERATURE AND OVER 400 PSIG PRESSURE
CORROSION RATE (INCHES PER YEAR)
CARBON STEEL AND LOW CHROME STEELS
12% CHROME STEEL
18% CHROME - 8% NICKEL STEEL
HYDROGEN SULFIDE CONCENTRATION (PER CENT BY VOLUME)

FIG. 7. Anticipated maximum corrosion rates in hydrodesulfurization equipment.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TUBES OF 1¼CR - ½MO
600 PSIG
REFRACTORY LINING AND 18CR - 8NI TYPE 347 INTERNALS
REFORMER REACTORS
PIPING OF 1¼CR - ½MO

FIG. 8. The metallurgy of a catalytic reformer.

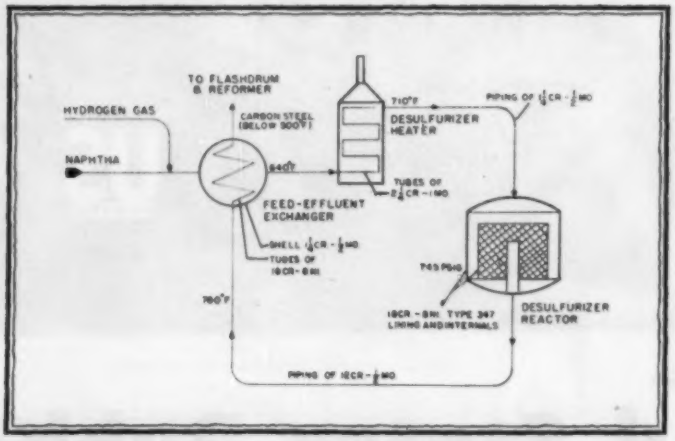

FIG. 9. The metallurgy of a hydrodesulfurizer.

and heat exchangers would be even higher. Amine scrubbing of the desulfurizer recycle gas reduces the hydrogen-sulfide content to below 0.012 per cent by volume in the recycle gas, to 0.010 per cent by volume in the combined feed, and to 0.25 per cent by volume in the desulfurizer-reactor effluent.

Desulfurizer metallurgy: Even should 10 per cent of the sulfur in the naphtha feedstock crack to hydrogen sulfide in the heater, predicted maximum corrosion rates from Fig. 7 are still low enough to permit the use of low-chrome steels in heater tubes and transfer lines ahead of the reactor. The desulfurizer reactor is lined with 18-8 chrome-nickel alloy, type 347; the reactor internals are also of this material. For the reactor-effluent transfer lines, 12 chrome-½ molybdenum steel was selected. For the effluent-exchanger tubes 18-8 chrome-nickel alloy was selected. Again, carbon steel is used throughout below 500 F. The metallurgy is shown in Fig. 9.

Other features: We have seen that scale stability is desirable in minimizing corrosion rates. Oxidation causes scales to shrink and spall off and it exposes bare metal to high initial corrosion rates by the returning sulfide reaction. For this reason, alternate oxidizing-reducing conditions in the heaters are avoided in the regeneration step. Also, air is excluded from the feed tanks by gas blanketing, which reduces the fouling of heat exchangers and heater tubes.

Continuous corrosion evaluation: Preparations have been made for continuous corrosion evaluation. The severity of corrosion can be diagnosed from operating conditions, quantitative analyses for corrodents, and corrosion-rate measurements. There is enough flexibility allowed for in design to take counteracting steps if necessary without waiting for damage to appear at inspection. These are the strong points of applying corrosion control in the design stage of a unit.

Acknowledgment

The authors wish to express their appreciation to Richfield Oil Corporation for permission to publish this paper. Thanks are due to E. C. Herthel for his guidance in the planning and coordination of all phases related to the new units, including the corrosion study. We are indebted to Sinclair Research Laboratories for use of some of their corrosion-rate data.

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2. E. Dittrich, "Uber den Einfluss des Druckes beim Angriff von Schwefelwasserstoff auf Stahle," *Die Chemische Fabrik* 10 145-50 (1937).

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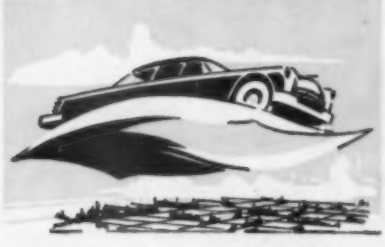

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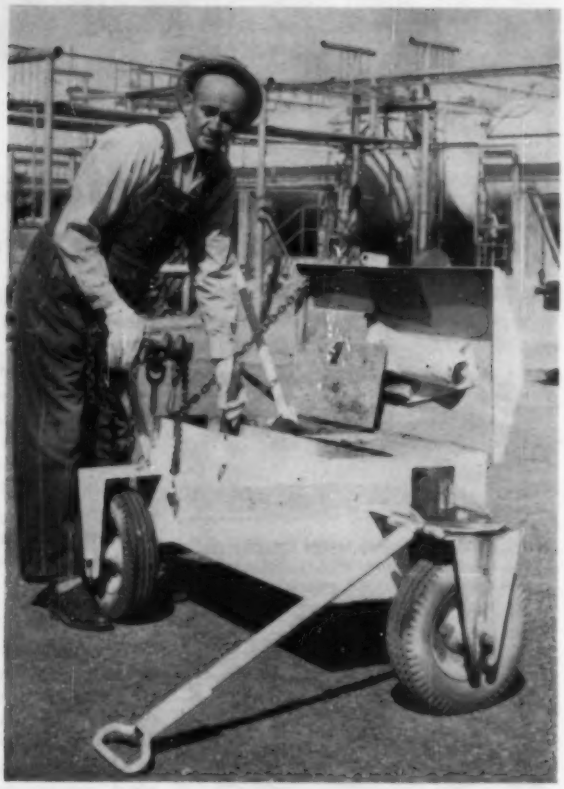
A neat tool box mounted on three rubber-tired ball bearing wheels that make it easy to pull eliminates the need for a pickup truck in making many repairs in the plant yard. The box, which was designed by J. W. Atkinson of Phillips Petroleum Company, has space for all sorts of tools, blue prints, etc.

Note that the box is made of light gage plate, and the brackets for the casters are welded to it. The caster for the front wheel swivels and the handle made of pipe and bar steel is hinged to the caster.



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Here's one made from an old axle housing of a truck and a piece of 3-in. railroad track. The base of the anvil stand is the brake drum from the same housing welded onto it as shown.

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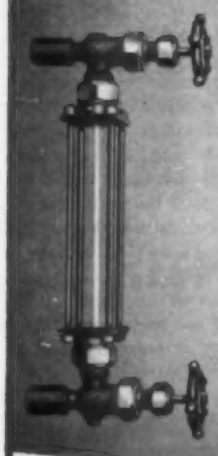

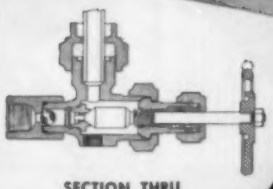

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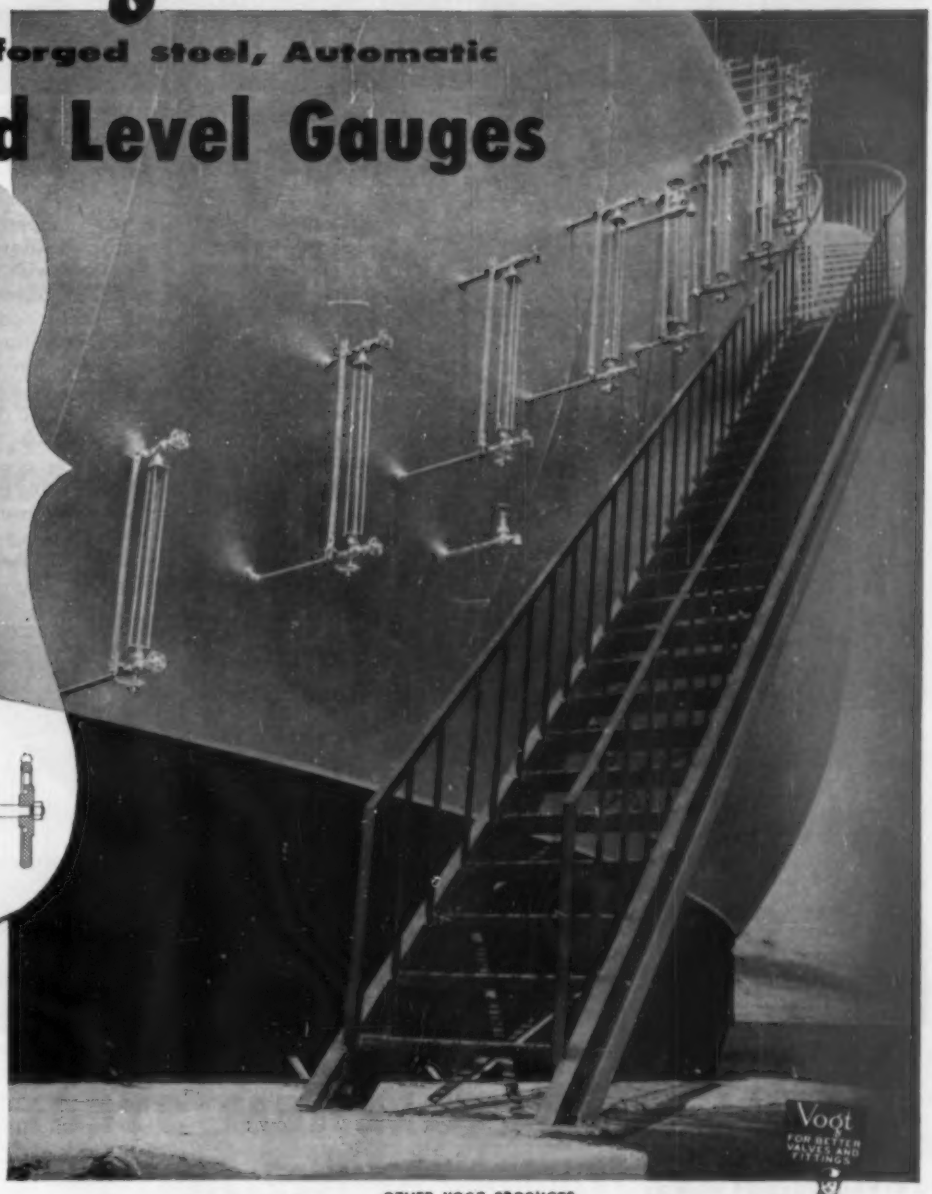

See Catalog F-9 for complete data on gauge cocks, trims, and gauge glasses for specific operating conditions or write Dept. 24A-FRE.

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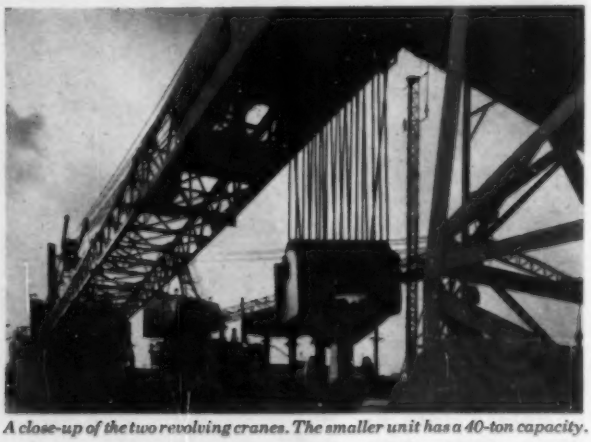
Humble Oil & Refining Company's new Derrick Barge, "DB-1," was designed to facilitate deep-water oil drilling operations. 300 ft long, 90 ft wide and 19 ft 1-in. in depth, the craft has two revolving cranes mounted on the main deck, one of 250 tons capacity and the other of 40 tons. It is equipped with electric generators, steam boilers, welding apparatus, various construction tools and all necessary deck machinery for mooring. The craft also has a two-level construction foreman's office, an elevated helicopter landing platform and comfortable, air-conditioned crew's quarters for 58 men.

Constructed and equipped by Bethlehem at Beaumont, the "DB-1" is an excellent example of the specialized craft designed and built by this yard for the oil industry.

If you have an offshore problem your *best bet all ways* is Bethlehem at Beaumont. Your inquiries are invited.



A close-up of the two revolving cranes. The smaller unit has a 40-ton capacity.

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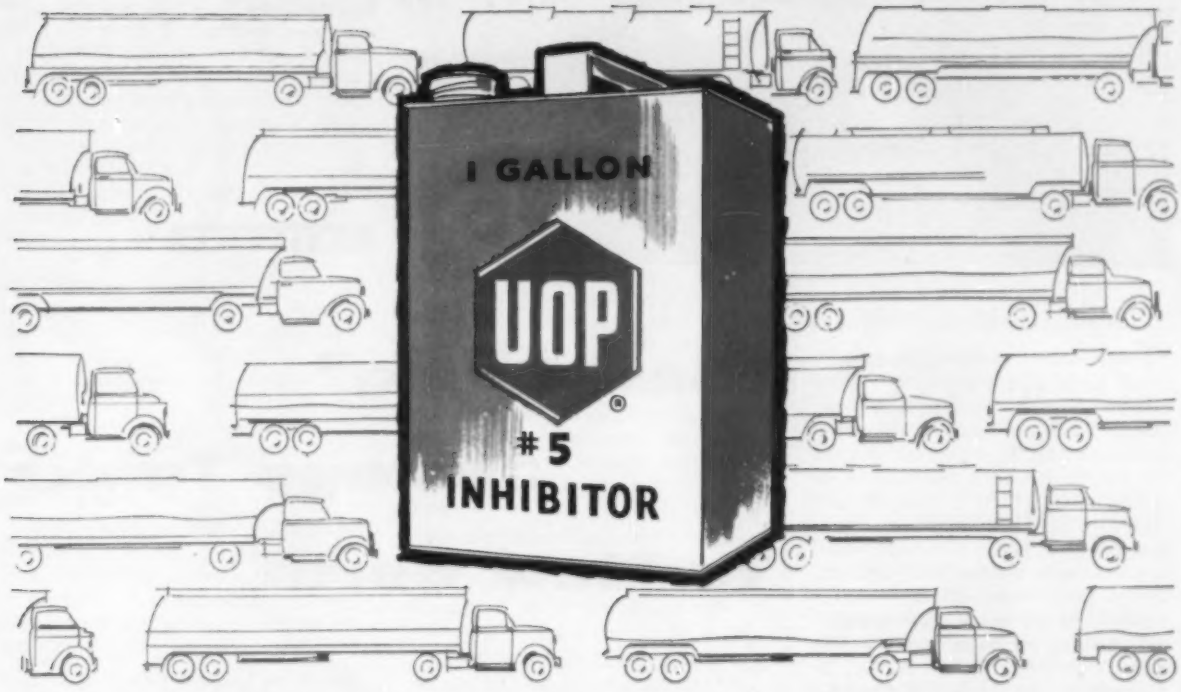

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British Correspondent

"FROGMEN" and a specially built canal were used recently at Shell's Stanlow, England, plant to shift 10 oil storage tanks a distance of 500 yards. Each tank weighed about 300 tons and was capable of holding 9000 tons of oil.

The tanks, 118 ft in diameter and 40 ft high were built in 1941 for gasoline storage. Today's development plans, however, called for their removal from their original site to another, as the space they occupied was required for further plant expansion.

Conditions on the site and the locations to which the tanks had to be moved made it necessary to use three different moving methods. The first 4 tanks were skidded on rail tracks to their new site. The fifth tank was cut into sections and re-erected by welding. For the last 5 tanks, a special canal was constructed.

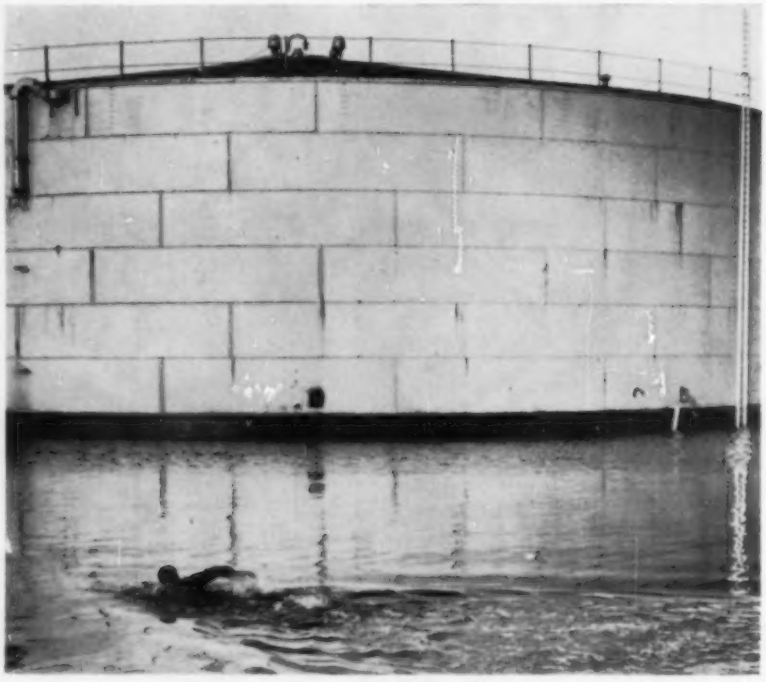
It was designed to connect the new and the old tank compounds and was 50 ft wide and 500 yards long. To fill it, 24,000,000 gal of water were pumped from a neighboring river.

The canal and tank compounds were flooded to a depth of 3 ft 6 in., sufficient to buoy up the tanks, which had a draft of approximately 2 ft. Tanks were rope-hauled manually, with tractor teams standing by just in case they got out of hand due to wind pressure.

Throughout the "trip," men were stationed on each tank roof to "let go the anchors" when the tanks were over their new foundation areas. "Anchors" were lengths of steel piping.

Frogmen were employed to locate the tanks accurately over their correct positions and to release snagged ropes.

As soon as each tank was positioned, its "sea-cocks" were opened to allow it to slowly sink to its foundations. When the job was completed, canals were drained, walls demolished, and the site cleared for further refinery expansion. * * *



A "frogman" takes off to free a snagged hawser.

New Projects

In Refining

A $10,000,000 contract with the Refinery Engineering Company, Tulsa, for construction of six major new units at the D-X Sunray refineries in West Tulsa and Sunray Village, Oklahoma, has been announced by D-X Sunray Oil Company. A 20,000 bbl per day Unifiner, a 12,000 bbl per day Platformer with a rerun tower, a 1417 bbl per day LPG recovery unit, a 2453 bbl per day butane isomerization unit, and a 2470 bbl per day HF alkylation unit will be built at the 70,000 bbl per day West Tulsa, Oklahoma, refinery. At the 40,000 bbl per day Sunray Village refinery, TRECO will construct a 6000 bbl per day Unifiner, to be used for pretreating naphtha. Completion is tentatively scheduled for the last quarter of 1957.

A giant fluid catalytic cracking unit will be built at The Texas Company's Port Arthur, Texas, refinery. The new unit will have a rated capacity of 90,000 bbl per day, including 30,000 bbl per day of recycle stock.

Texaco is also building an 80,000 bbl per day vacuum pipe still at Port Arthur, Texas, to replace existing units having daily capacity of 60,000 bbl. There will be a 20,000 bbl per day increase in the refinery's crude capacity.

A second 21,000 bbl per day Ultraformer will be built at American Oil Company's Texas City, Texas, refinery. Construction will begin in April of 1957, with start-up planned for early 1958. Equipped with integral feed-desulfurization facilities, the new Ultraformer is being built to further increase the quantity and quality of American's unleaded premium gasoline.

Phillips Petroleum is building a 3000 bbl per day fluid catalytic cracking unit at its Great Falls, Montana, refinery. The project is scheduled to be "wrapped up" in the spring of 1957.

Mining of underground storage caverns for propane is underway at Esso Standard's Bayway, New Jersey, refinery. The 300,000 bbl facility is being mined from a red shale formation underlying the refinery. The storage caverns will be 300 to 350 ft deep with a unique system of looping tunnels designed to ease operations, cut mining costs. Fenix and Scisson, contractors from Tulsa, Oklahoma, are doing the work.

Alaska's first refinery will be built at Haines by Shamrock Petroleum Company, Ltd. Surveys have been completed and initial site preparation is underway.

British American Oil Company has awarded to Fluor Corporation of Canada the contract for construction of offsites required for a new catalytic reformer and crude units being built at B-A's Clarkson, Ontario, refinery. The $4,000,000 project is scheduled for completion next year. The new units will boost the Clarkson refinery's capacity to 61,500 bbl per day.

Anderson-Prichard Oil Company is expanding its Arkansas City, Kansas, refinery by 5000 bbl per day. Existing crude capacity is being replaced with a new 25,000 bbl per day crude unit while catalytic cracking capacity will be increased from 5000 to 7500 bbl per day.

Catalytic Construction Company has received the contract for handling maintenance work at Tidewater Oil Company's nearly completed 130,000 bbl per day refinery at Delaware City, Delaware.

Petrochemicals

Union Oil Company has started construction on an ethylene plant at its Los Angeles refinery. The annual capacity will be 100,000,000 lb, with a substantial portion being delivered through a three-mile pipe line to the polyethylene plant now being built by Koppers Company and Brea Chemicals, Incorporated.

A $5,000,000 styrene plant will be built near Odessa, Texas, by the Odessa Styrene Company. It is the final part of a major synthetic rubber manufacturing facility, with the styrene and butadiene to be used in a coploymer plant now being built by El Paso Natural Gas, General Tire and Rubber, and Odessa Natural Gasoline. Odessa Styrene was recently formed, is 75 per cent owned by El Paso Natural Gas Company and 25 per cent by United Carbon Company.

A joint petrochemicals project is being studied by Columbia Gas System and Commercial Solvents Corporation.

Magnolia Petroleum Company recently completed its 1,200,000 bbl LPG underground storage facility near Hull, Texas. It operates in conjunction with Magnolia's Beaumont, Texas, refinery. Pumping of salt water stored in this 385,000 bbl pit into the underground storage wells forces the LPG to the surface.

Architect's drawing shows how new engineering building of Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, will look when completed at South Charleston, West Virginia, in 1958. Building will house more than 500 engineers and will be adjacent to a new development laboratory.

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FIG. 21 LIP-MOLD

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Under investigation is the construction of a 40 to 50,000,000 dollar project in the Ohio Valley area, beginning in early 1957. Long range plans provide for formation of a jointly owned company, recognize the possibility that the new company may ultimately be engaged in the entire field of ethylene and other hydrocarbon derivatives.

Ethyl Corporation is building an antiknock compounds plant in the San Francisco Bay area. The capacity will be large enough to satisfy the increasing demands of West Coast refiners, according to releases.

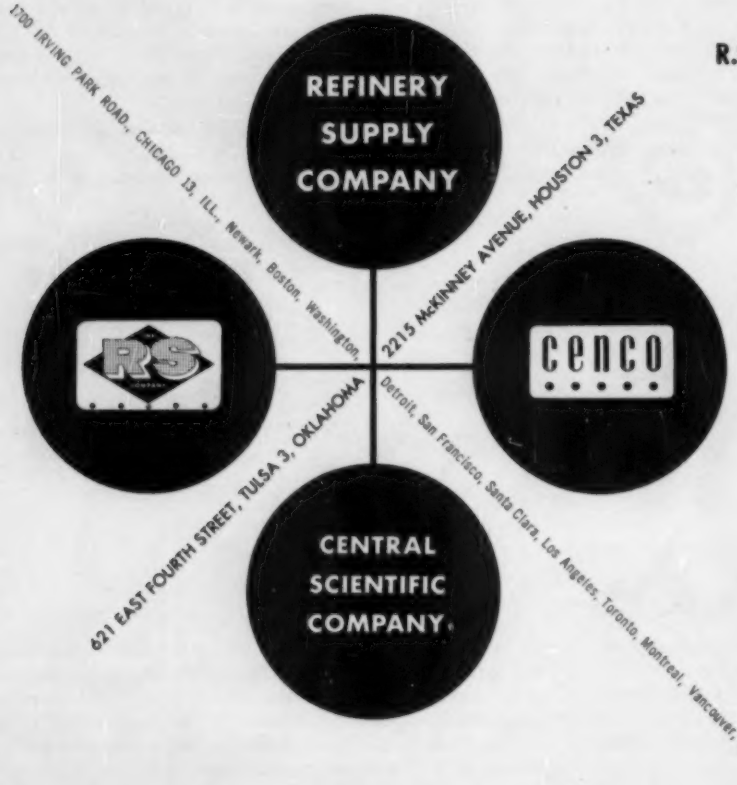
Petroquimica Cubana, S. A., is planning to start building the first units of a $10,000,000 petrochemicals plant at Santiago before the end of the year. The initial units will cost about $2,000,000 and will produce caustic soda, chlorine, and hydrogen, are the initial phase of a seven-year construction program.

British Hydrocarbon Chemicals, Ltd. has authorized the design and construction of a 25,000,000 lb per year polyethylene plant at Grangemouth, Scotland. The plant will use Phillips Petroleum Company's new catalytic process.

Jefferson Lake Chemical Company, through its wholly owned subsidiary Merichem, is expanding its petrochemicals activities. The Merichem plant, on the Houston ship channel, is doubling its phenol and cresylic acid capacity to 300,000 gal per month. Production of the plant's other major product, sodium sulfide, is being quadrupled to 1000 tons per month. Cost will be about $2,000,000. Second phase of the expansion will be a new $3,500,000 petrochemical plant, to be built elsewhere on the ship channel.

The Fluor Corporation is now soliciting contracts for research in the petroleum, chemical and petrochemical fields. Heretofore, Fluor's research efforts centered only on problems associated with the company's process engineering contracts or for development of new products for manufacture by the company's products division.

More West Texas products will find their way to the Gulf Coast. Gulf Oil Corporation has started construction of a products system to link its West Texas and Southeast New Mexico plants with the Gulf. Parts of the system will be new line, others will be converted crude trunks. Primary shipments will be gas liquids, the second system in this service. Magnolia has been using a converted crude system since the beginning of the year to move gas liquids into high-demand areas along the Gulf Coast.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CENTRAL SCIENTIFIC COMPANY

R.S. PORTABLE DEAD WEIGHT GAUGE

the practical and accurate method of checking

- **Line Pressures**
- **Rock pressures at wells**
- **Static pressure on orifice meters**
- **Gas pressures on pipe line leakage tests**

This instrument is based on the principle of generation of pressure by application of a known weight to a hydraulic piston on known area. Conversely, an unknown pressure can be measured by balancing its force on a piston of known area with a known weight—the result is extremely accurate pressure readings.

EXCLUSIVE

Present Fuels Not On Way Out Say SAE Leaders

PRESENT-day car engines, and the fuels that power them, are not dead yet, leaders in the oil refining and automotive industries said at the National Fuels and Lubricants meeting, Society of Automotive Engineers, November 8-9 in Tulsa, Oklahoma. Gas turbines and free-piston engine designs are making great strides but their general adoption by the industry and customers as primary power plants is still a long way off.

Economic as well as technologic considerations govern this situation. Too much has been invested in our current facilities, design and manufacturing establishments to permit a quick switch to these other newer power units. Even the "new" fuel injection systems cannot be called a trend as yet. General Motors plans, however, to be in mass production on gasoline injection systems for Chevrolet cars soon.

Oil refiners will continue to make high octane fuels for motor car and aviation consumption, and engine builders will continue to make high compression engines to use those fuels. All this is considered axiomatic by the nearly 600 engineers present at the meeting. Forward-looking automotive and refining companies must keep abreast of these new developments.

New Engines May Be Choosy

Our new high-efficiency engines can, or may be, fussy about their fuels. It is necessary that we keep engines and fuels out of the surface-ignition range, and this result may be attained in the future at the expense of other desirable factors in engine-fuel efficiency.

With the current volatility level of present winter gasolines, cold starting at down to zero F is said to be no problem. At lower temperatures volatility is an increasingly important factor; recent engine designs show a longer warm-up period than older units. V-8 engines are often more critical than the older in-line engines. Cost of gasolines may rise if present volatility levels are to be maintained. Refiners are now using more catalytically cracked and reformed high-octane number components, of necessarily lower boiling range in their gasolines, which militates against higher volatility of the overall fuels. Private discussion as well as public indicates that automotive designers are loath to see higher front-end volatility because of what they claim will be added production costs for cars. Style designs are causing the power plant engineer more and more trouble in finding proper, adequate cooling in the continually more constricted engine compartment.

What Causes Knock?

More insight into the causes and mechanism of fuel detonation has been obtained by study of fuels and knocking, using a new rapid-compression machine developed at MIT over a period of years. Data show that tetraethyllead has considerable thermal stability, requires temperatures of around 700F to decompose. It is observed also that TEL is effective in increasing the autoignition-limited compression ratio only as it decomposes at a time before the unleaded fuel will autoignite.

Lubricant properties can play a large part in reducing the octane requirement of an engine, it has been found. This is true regardless of whether the engine is spark-knock or surface-ignition limited. In a laboratory study using primary reference fuels, a given oil, which was not blended with a "modified detergent," was surface-ignition limited. Another oil containing the modified detergent was definitely spark-knock limited in the field, which confirmed the laboratory findings. The modified detergent was referred to as the "Barium-P_2S_5-olefin type," that is, a product containing barium, phosphorus pentasulfide, and an olefin complex.

The addition of viscosity index improvers lowers oil consumption in present engine designs. Also, engine conditions and operating characteristics may have a much greater effect on consumption than does the oil's viscosity grade. High-speed tests emphasize oil volatility, road tests emphasize oil viscosity. Researchers believe that just because multigrade oils have shown good results we should not stop work on their improvement.

Bearing wear in engines is most severe during starting, and at extreme high speed operation; it is lower with an SAE grade 30 oil than with an SAE 10W oil, and in turn is lower with an SAE 10W-30 grade oil than with an SAE 30 oil. The most outstanding advance made in recent years in studying wear is by the use of radioactive tracers as irradiated bearings in engine tests. For example antimony-124 isotope has a half-life of 60 days, and high "radiation energy," and has been used to great advantage recently in this research.

Requirements for gear lubricants have increased in severity and future universal or all-purpose gear oil must have a higher level of high-speed activity, if it is to meet coming demands for load-carrying capacity. Suitable oils are available as bases for these gear oils. The new L-37 test method is basically sound, and the development of test procedures is progressing satisfactorily, engineers say.

Altitude and Octane Numbers

Influence of altitude above sea level on octane number demands of car engines follows the pattern found by earlier investigators. Tests in Peru, run from 600 ft to 13,400 ft altitude showed that at the lowest level, four cars needed an average of 82 octane number by the Uniontown method. At 6500 ft the same cars needed only 57½ octane number; at 10,000 ft fuels of average 41 octane number served satisfactorily. At 13,400 ft (2½ miles up), 14 octane number sufficed, with one car running on normal heptane, zero octane number, without knocking! In Montana, octane requirement ranged from 73 at 3300 ft, 66½ at 5000 ft, 59½ at 6500 ft and down to 40 at 10,800 ft. Comparison of these data with Bureau of Standards findings and extrapolations shows that while both sets of data agree fairly well at the lower levels, the Bureau's extrapolations are too high, by 6 to 15 numbers above 10,000 ft.

It is found that cold starting is independent of ambient temperature or fuel volatility with winter fuels at 20F and above. Below 20F cold starting improves with increasing front-end volatility. Warm-up performance is affected largely by the 50-70 per cent evaporated section of the ASTM distillation curve and only slightly by either front-end or final volatility.

REFINING AND PETROCHEMICAL PERSONALS

F. B. Odasz

Frank B. Odasz has been promoted to manager, development and control, for Husky Oil Company. Formerly assistant director, technical service, Odasz joined Husky in November, 1947, as research chemist.

He is quite well known for his technical articles both in the field of statistical controls and asphalt product development. Prior to joining Husky, Odasz served as research assistant at the University of Michigan and research engineer for Parmelee Motor Fuel Company in New York City.

Richard E. Lauterbach, manager of manufacturing for the General Petroleum Company, has been elected president of the Engineers Club of Los Angeles, California. Lauterbach, former manager of General Petroleum Ferndale Refinery, has been associated with the oil industry for the past 20 years.

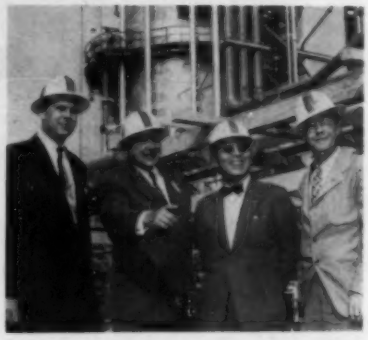
Other officers elected at the meeting of the board of directors are **Robert F. Stewart,** sales manager of Western Precipitation Corporation, as vice president; **Eugene R. Johnson,** of Western Precipitation Corporation, as secretary; **Wallace W. Kenney,** sales engineer for Graybar Electric Company, as treasurer. **Al Farley** will continue as manager of the club's headquarters in the Biltmore Hotel.

Past President **Maurice L. Dickinson,** chief hydraulic engineer for the Bechtel Corporation, was unanimously elected to the chairmanship of the board of directors. Other directors are **Milan G. Arthur,** chief valuation engineer for the Union Oil Company; **Finley B. Laverty,** chief hydraulic engineer for the Los Angeles County Flood Control District; **Thomas F. Edson,** consulting engineer; **Richard F. O'Mara,** consulting engineer; and **J. W. Savage,** electric utility engineer for the Westinghouse Electric Corporation.

Shunichi Takeuchi, leader of a top management study team of prominent Japanese industrialists brought to this country by the International Cooperation Administration, recently toured Tidewater Oil Company's refinery of the future.

Takeuchi, who is president of the Mitsubishi Oil Company, Kawasaki, Japan, in which Tidewater holds a 50 per cent interest, was given a preview of the latest designs in oil refinery units as he toured the Delaware Flying A Refinery, now nearing completion 15 miles south of Wilmington, Delaware.

Pictured with Takeuchi (third from left) is **George C. Caine** (second from left), **James McDonald** (left) and **Benjamin G. Jones** (right). Caine serves as manager of the manufacturing department while McDonald and Jones are assistant managers of the refinery.



As part of a corporation program of more effective and complete delegation of authority to the local level, Gulf Oil Corporation has reorganized the major managerial assignments at its five domestic refineries. Top personnel at Gulf refineries are:

At Port Arthur, Texas, **R. C. Faulkner** is general manager with **F. L. Bryan,** manager-services; **T. F. Hogan,** manager-operations; and **H. M. Vaughan,** manager-engineering. At Staten Island, New York, **William M. Braybrooks** is general manager with **F. C. Fichtl,** manager-services; and **A. H. Grant,** manager-operations. At Toledo, Ohio, **D. E. Hart** is general manager with **R. P. Ricketts,** manager-services; and **H. A. Bailey,** manager-operations, and **J. K. Warne,** manager-engineering. At Cincinnati, Ohio, **A. A. Niehenke** is general manager with **R. P. Petrick,** manager-services; **L. L. Laster,** manager-operations; and **W. S. Reeder,** manager-engineering.

PUMP

Liquids • Gases • Slurries

WITHOUT CORROSION OR CONTAMINATION

Prices range from.....$55 to $500 depending on size of pump and accessory equipment required.

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SIGMAMOTOR Inc.

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LONG, TROUBLE-FREE SERVICE

Here's the simplest and most efficient pump valve made for reciprocating pumps. The ROYAL CROWN PUMP VALVE has only three separate parts, yet its performance is revolutionary! Valve is guided by a frictionless ball stem which allows it to oscillate and turn with the fluid stream. Swings completely free with each stroke of the pump . . . seating each time in a new position. Resistance to fluid is reduced to a minimum which means greater pump volume at less pump speed. Adaptable to all reciprocating pumps . . . handles all types of liquids.

Royal Crown PUMP VALVES

(A) Round valve surface is streamlined. No obstructions to restrict the flow. (B) Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing . . . a lapping action, a continuing perfect seat. (C) Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

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Personals

John W. Lane, automotive manager, lubricating department, Socony Mobil Oil Company, Inc., was elected president of the National Lubricating Grease Institute at the closing session of the organization's twenty-fourth annual meeting at the Edgewater Beach Hotel, Chicago, Illinois.

Lane was vice president and chairman of the program committee for the meeting. He succeeds **W. M. Murray,** Kerr-McGee Oil Industries, Inc., Oklahoma City, Oklahoma.

Rudolph Cubicciotti, vice president of L. Sonneborn Sons, Inc., New York City, was elected vice president, and **A. J. Daniel,** Battenfield Oil and Grease Corporation, Kansas City, Missouri, was re-elected treasurer. **Thomas W. Miller,** Kansas City, Missouri, was reappointed executive secretary.

W. T. Herget

H. A. Parker

Walter T. Herget has been promoted to a newly created position of manager of operations in the manufacturing department of American Oil Company. Herget, now general superintendent of the company's new Yorktown, Virginia, refinery, will make his headquarters in the company's general offices in New York City.

He will be assisted by **H. A. Parker,** former technical director of the Destrehan, Louisiana, refinery, who has been promoted to the new position of assistant manager of operations.

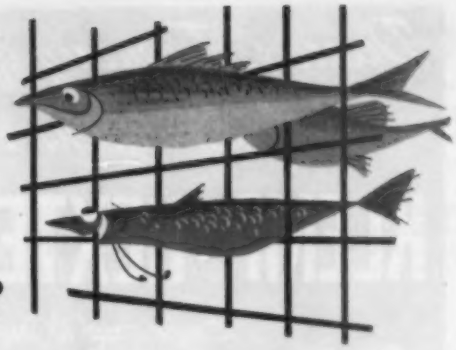
Forrest H. Blanding has been named head of the newly created distribution and exploratory research section of Esso Standard Oil Company's economic and marketing research division.

Blanding, who has been with the company since 1940, previously headed the correlations and special studies section in the process research division of the Esso Research and Engineering Company, Linden, New Jersey.

S. W. Darling has been appointed superintendent of The Texas Company's West Tulsa works, to succeed **E. M. Reynolds,** who has retired. Also announced was **J. J. Rasor,** special representative for Liquid Petroleum Gas Sales at Tulsa, Oklahoma, who has been appointed assistant superintendent of the West Tulsa works to succeed Darling.

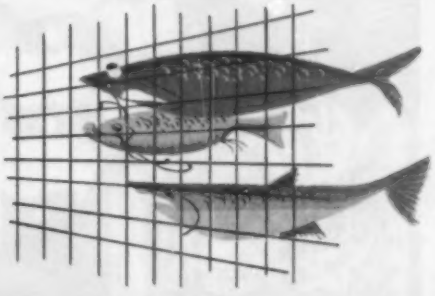
E. W. Masters has been appointed a director and consultant for the Great Lakes Oil & Chemical Company. Associated with the oil business for many years, the last 30 years being with Shell Oil Company, he will be actively engaged in the operations of the Great Lakes Company.

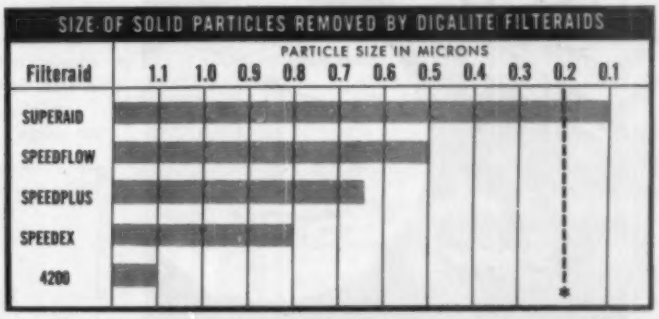
What good is a net that the fish swim THROUGH?



The major difficulty in securing trouble-free flood water is not the larger impurities, easy to precipitate or settle . . . it's the little devils which can slip right through when ordinary separation processes are used. These microscopic hellions . . . algae, bacteria (especially the sulfate-reducing bacteria) and chemical precipitants . . . find happy homes in the pores of the formation, grow there, increase and multiply till the formation is plugged and the water drive practically destroyed.

But they can't get through DICALITE!





***0.2 MICRON**—Theoretical limit of resolution of optical microscope. Few microscopes achieve it.
80.0 MICRONS—Smallest particle size visible to the unaided eye at 10" distance.

That's why many of the diatomite filter systems now operating on water flood projects use Dicalite Filteraids. As the chart shows, there's a Dicalite grade to filter out unwanted particulates of any size—algae, bacteria, colloidal solids—even down in the submicron range. Simple tests made by Dicalite service engineers can quickly indicate the grade and amount required for any desired clarity at optimum flow-rate.

Diatomite filter systems for water flood projects occupy only 1/5th the space of a sand system, and can be completely unitized. Capital investment is usually lower, too. So, if pump pressures are steadily rising and the water drive is slowing, investigate the many advantages of Dicalite in a diatomite filter system. Write for full information.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

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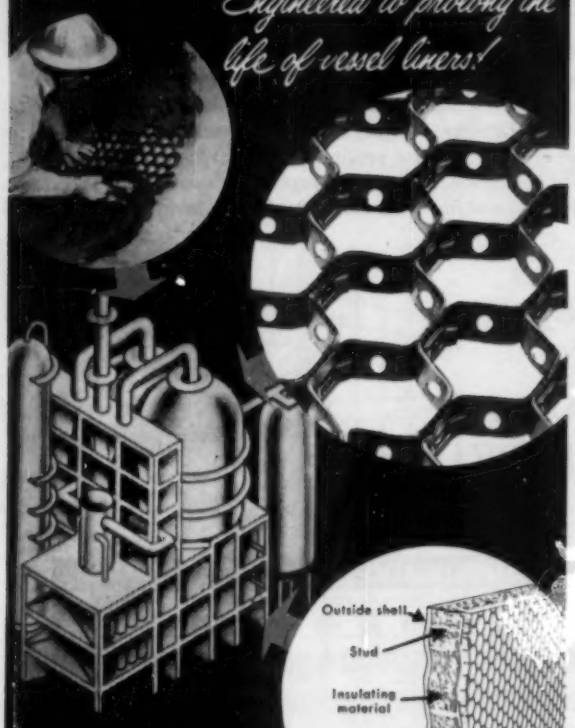
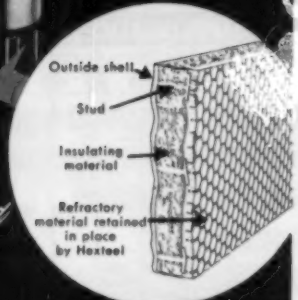
KLEMP HEXTEEL!

Engineered to prolong the life of vessel liners!





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HEXTEEL is a steel armor and retainer for castable refractory monolithic linings used for cat crackers, reactors, regenerators, fractionators, heaters, strippers, risers, stacks, cyclones, ducts, breeching, furnaces and tanks . . . . Our engineering department is prepared to design your total lining requirements. Fabricated in carbon or stainless steel.

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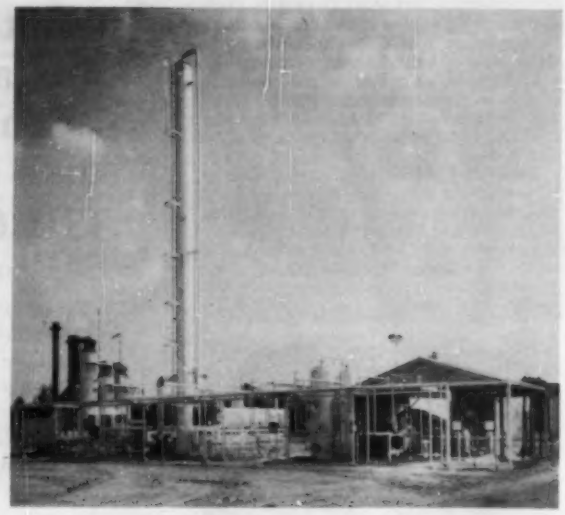


. . . was this photograph of the South Hampton Company's Platformer. The unit, near Silsbee, Texas, receives light natural gasoline feed stock from the adjoining South Hampton cycling plant, upgrades it to high-quality blending component for premium gasolines. Although the cycling plant and the Platformer are separately owned, operation is virtually integrated. Product, however, is piped to another plant about four miles away.

The gas-engine driver at the right powers both the feed pump and the hydrogen recycle compressor. Automatic controls permit unattended operaton, but a complex alarm system will signal operators living in nearby houses in the event of emergency. Safety devices assure safe, automatic shutdown in the event of high furnace stack temperatures, loss of feed, low levels in surge and separation drums, or loss of cooling water.

Details of the plant are described in an exclusive story on page C-9.

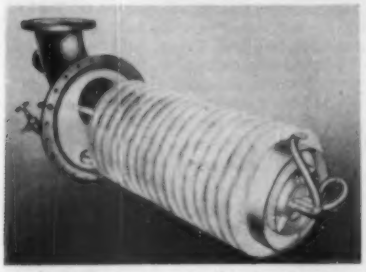
"Let's go find out what valves to turn *this* time —

NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(41) Coil With 540 Sq Ft Heating Surface. A special heat exchanger containing 540 sq ft of heating surface but occupying



only 7.2 cu ft of space has been designed and built by Schutte and Koerting.

Unit, when installed, will heat 3000 cu ft of vapor per minute, using 450 psig steam inside the tubes. Size of the radiafin coil bundle is only 40¾ in. long by 19¾ in. in diameter.

Schutte and Koerting Company.

(42) Corrosion Meter. Developed by Crest Instrument, the Corrosometer, as it is called, measures electrically the progress of corrosion in any corrosive system.

Meter is used in conjunction with special probes containing metal specimens which are subject to corrosion. Three models of the meter are manufactured: Model "C," which is a completely portable field unit; Model "K," which is designed for laboratory use and in plants, and Model "R," which is a continuous recording unit.

Crest Instrument Company.

(43) Transfer Line Switchboard. A system of flexible hose links combined with quick-connect "snap-on" hose couplings manufactured by Titeflex forms the heart of a new fluid transfer system.

Using these snap-on flexible hose links in place of multiple-valve installations, conventional fixed pipe lines are run to a central point where the flexible links can be rapidly shifted from one piping line to another, resulting in a switchboard-like arrangement. Such "piping switchboards" are applicable in chemical, oil refining, and other processing plants, where they meet all requirements for practical application in high-capacity, high-pressure fluid lines.

Quick-Seal coupling is claimed to be leakproof at low and high pressure, free of internal obstructions so as to cause only slight pressure drop in the line, and practically maintenance free.

With the "switchboard" system, any number of processing units can be connected to perform the same operation simultaneously, or material can be sequenced through any desired order of processing operations. It is now possible to design switchboard-type liquid transfer systems which cost much less to construct, require much less space, and provide many plant operating advantages (such as improved safety) over the conventional valve-manifold type of liquid piping systems.

Titeflex, Inc.

(44) "Cable Car" Hoist. The Ohio "Cable-Car," Swing-Stage Traction Hoist is new in principle and applications; however, it has been laboratory and field tested for the past two years.

Hoist is currently being used in refineries, inside and out of oil, water, and gas storage tanks, grain elevators, stacks and ships as well as on signs, bridges, buildings, and numerous other structures.

Ohio Hoist & Mfg. Co. Inc.

(45) Check Valve for PVC Piping. A check valve made of polyvinyl chloride for handling corrosive gases, vapors, and fluids has been developed and introduced by Techno.

Called Technocheck — PVC, the valve employs a unique principle used by the company in the manufacture of its metal check valves.

Techno Corporation.

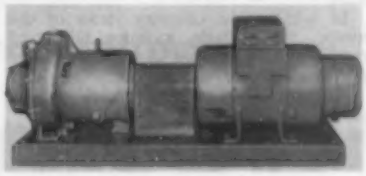
(46) Positive Displacement Valve. A new method of accurately measuring and controlling flow of liquid or gases has been announced.

"Positive Displacement Valve" combines the advantages of a standard four-way valve yet is said to afford absolute pre-measured accuracy and flow-control.

Incorporating the precise and accurate measuring advantage of a cylinder and piston arrangement with the flow controlled by a hydraulic brake, the PD Valve offers a wide combination of measuring or dispensing facilities in any pre-determined volume. It permits measurement and dispensing from two sources to one common discharge, from two sources to two discharges or from one source to one discharge.

The Punxsutawney Company.

(47) Turbo-Alternator for Operation or Stand-by. Sixty-cycle alternating current can now be produced for regular or stand-by requirements by a "turbo-alternator"



that combines mechanical drive turbine, generator, exciter, and voltage regulator in a single unit.

Manufactured by Pyle-National in 3.75 to 25 kva capacities, single or three phase and 120/208, 240 or 480 voltages, unit can be furnished drip-proof, splash-proof, and explosion-resistant.

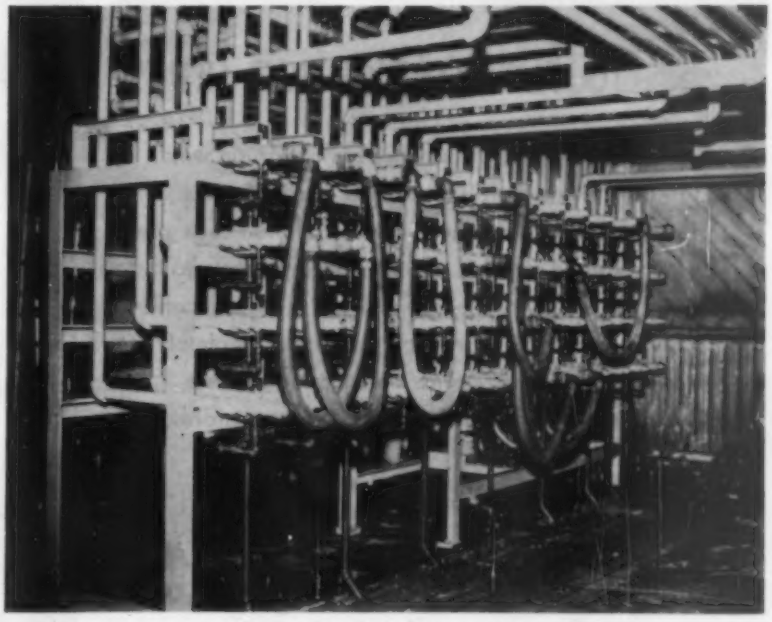
The Pyle-National Company.

(48) Gasoline Injection. Development of a gasoline fuel injection system for internal combustion engines has been announced by Borg-Warner.

Fuel injectors, which may eventually replace the conventional carburetor on cars, trucks, and tractors, are currently commanding special attention throughout the automobile industry.

In an engine equipped with fuel injection, precisely metered amounts of fuel are sprayed directly into the air in the intake manifold at a point just before it enters the cylinder. Air for the air-fuel mixture is brought to this point separately and does not mix with the fuel until the two meet at the combustion chamber opening.

Borg-Warner Corporation.



Transfer line "switchboard" of Titeflex' flexible hose link system.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(49) Explosion-Proof Motors. Latest design features of Allis-Chalmers explosion-proof motors in NEMA rerated ratings of ½ to 30 hp (Type GZZ) and in non-rerated ratings of ½ to 100 hp (Type APZZ) are described in a company bulletin.

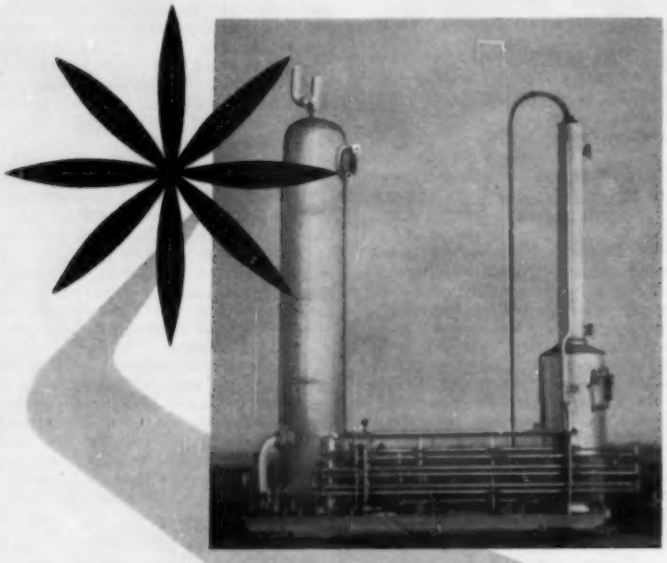
In addition to cutaway views of the motor, the bulletin includes tables of ratings and dimensions as well as a horsepower frame chart.

Allis-Chalmers Manufacturing Company.

(50) Direct Air Oxidation Process for Ethylene Oxide. An 8-page brochure describes the process developed by Scientific Design for production of ethylene oxide by the direct air oxidation of ethylene.

The SD process makes the chlorohydrin process obsolescent. A complete flow diagram of the direct air oxidation process is presented. Two of the 8 plants using the SD process, built or being built, designed and engineered by SD, are shown.

Scientific Design Company, Inc.



* Sulfur extraction units

You can be assured of dependable operation with a McNamar sulfur extraction unit. With the purchase of a completely packaged unit, installation costs are greatly reduced. These units are simple to install and are easily moved to new locations. McNamar sulfur extraction units are completely automatic and require minimum attendance. Call, write or wire McNamar for further information.

McNAMAR BOILER & TANK CO.

Box 868 • CHerry 2-6291 TULSA, OKLA.

(51) Batch Control. Fischer & Porter has published a catalog describing the company's batch control systems. These systems offer simple, dependable means for automatically adding a predetermined volume of fluid to a batch process.

Fischer & Porter Company.

(52) Gas Chromatography for Plant or Laboratory. A 4-page company brochure describes the Burrell Kromo-Tog, Model K-3, for gas and vapor-phase chromatography in plant or laboratory.

Recommendations are offered for building up the basic unit to suit specialized needs. Illustrated, listed, and priced are all needed accessories, including fractionating columns designed and coiled for the K-3 and both activated solid and partition-type adsorbents for all chromatographic analysis.

Burrell Corporation.

(53) Automatic Water Filter. *AWF Filters for Complete Automation* is the title of a bulletin offered by R. P. Adams.

This 10-page bulletin is printed in three colors with cutaway sections and drawings to show the operation of the filter. Dimension charts and flow curves are given for all three sizes of AWF Filters and for Poro-Stone, Poro-Screen and Poro-Edge elements.

The R. P. Adams Company, Inc.

(54) Cobalt Molybdenum Catalysts. The catalyst department of Girdler has released a bulletin describing in detail its G-35 cobalt molybdenum catalysts for upgrading a wide molecular weight range of petroleum stocks by hydrogen treating.

Bulletin points out that naphthas, middle distillates, heavy gas oils and heavy oils can be upgraded with excellent results. General reactions are listed and described. Typical flow diagrams and reactions in hydrogen-treating petroleum feed stocks over Girdler G-35 cobalt molybdenum catalysts are included.

The Girdler Company, a division of National Cylinder Gas Company.

(55) Organic Chemicals. More than 335 organic chemicals are described in a 24-page booklet issued by Carbide and Carbon Chemicals.

Condensed data on applications are presented and physical properties are given in tabular form. An alphabetical index is included for the convenience of the user.

This 1957 edition of "Physical Properties of Carbide and Carbon Chemicals" features 21 new products.

Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation.

(56) Odor Control for the Petroleum Industry. Rhodia has published a 6-page booklet on "Alamask Odor Control for the Petroleum Industry." Data presented in the booklet are based on practical tests within the refining fields.

Alamask products are specially designed aromatic chemicals, compounded to provide the maximum in nonobjectionable odor coverage of malodorous materials which may be present in a petroleum product or may become air-borne during processing.

Brochure lists the various sources of objectionable odors in petroleum processing and products and recommends specific odor control chemicals to use.

Rhodia, Inc.

Photo shows convenient panel pull-out drawers

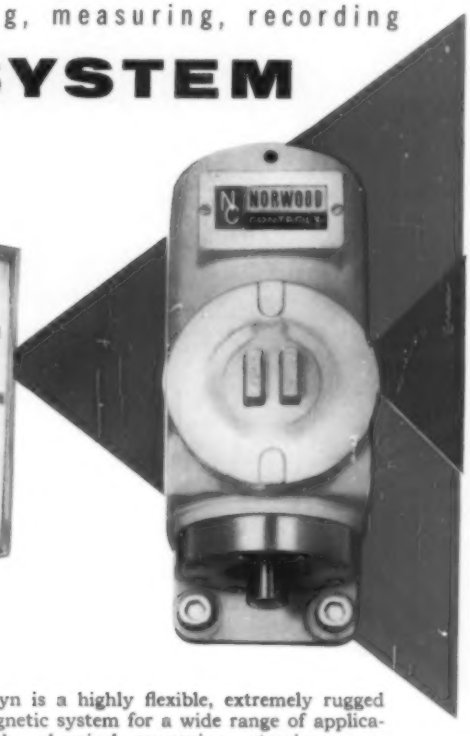
Copyright 1956 by Detroit Controls Corporation

HIGHer reliability
LOWer maintenance

ELECTROSYN

indicating, measuring, recording

SYSTEM



ElectroSyn is a highly flexible, extremely rugged electro-magnetic system for a wide range of applications in the chemical processing, atomic power, natural gas and petroleum transmission fields. It is designed to measure, indicate, record (including analog to digital conversions), or control pressure, differential pressure, flow, liquid level, temperature. Basic system comprised of signal transmitter, servo amplifier (magnetic), and Null Balance Indicator — no electron tubes or slide wires.

Leading pipeline companies are currently using ElectroSyn Systems for remote indication and data handling of pressures and flows. They point out that ElectroSyn is especially practical for pipeline compressor station applications because the system can withstand a static overload of 300% of rated pressure for a 1% zero shift, with a bursting safety factor of ten times rated pressure for ranges up to 1500 psi.

Complete technical information upon request.

NORWOOD CONTROLS

UNIT OF DETROIT CONTROLS CORPORATION

930 Washington Street · Norwood, Mass.

NC NORWOOD CONTROLS

TO YOU FROM THE MAKERS OF GASO PUMPS

Best Wishes for the Best of Everything

During the
Christmas
Season
and in the
New Year
Beyond

GASO PUMPS
for every oil industry need

GASO PUMP & BURNER MFG. CO.
Tulsa, Oklahoma

PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Humble Pipe Line Company Houston, Texas	95	18	Ector to Kemper, Texas
Interprovincial Pipe Line Company Toronto 1, Ontario, Canada	151 32.6	20 24	Sarnia to Port Credit, Ontario Regina, Saskatchewan, to Cromer, Manitoba
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
Northwest Pipe Line Corporation Salt Lake City, Utah	350	8	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Pasotex Pipe Line Company El Paso, Texas	127.5	20	New loop on system from Wink to El Paso, Texas
Rangeland Pipe Line Company Calgary, Alta., Canada	450	—	Sylvan Lake Area to Sundre (Central Alberta)
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Shell-Standard of California	600	14	Four Corners Area to Los Angeles
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Socony Mobil Oil Company de Venezuela and Sinclair Oil & Refining Company	211	20	Silvester field near Barines to Puerto Cabello, Venezuela
Tecumseh Pipe Line Company Independence, Kansas	190	20	East Chicago, Indiana, to Cygnet, Ohio
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory
Union Oil Company Los Angeles, California	225	12–16	Junction station to San Francisco, California

PRODUCTS LINES

Name of Company	Miles	Size	Location
El Paso Natural Gas Company El Paso, Texas	96.0	8	Gallup to Blanco Plant, New Mexico
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6-8	Edmonton to Fort William, Canada
Northwest Pipeline Corporation Salt Lake City, Utah	350	8	Four Corners area to Salt Lake City, Utah
Service-Continental-Sinclair-Phillips	550	—	Salt Lake City, Utah, to Spokane, Washington
Southern Pacific Pipe Lines, Inc. Los Angeles, California	315	6–10	Richmond, California, to Fallon, Nevada
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Union Oil Company of California	815	—	Shale Oil Plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Carolina Natural Gas Corporation Hickory, North Caroline	185	2–12	Additions in North and South Carolina
Cities Service Oil Company Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas
Coastal Transmission Corporation Dallas, Texas	562 272	22–26 Var.	McAllen, Texas, to Baton Rouge, Louisiana Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company Colorado Springs, Colorado	345 100 50	30 24 22	Kit Carson, Colorado, to Beatrice, Nebraska Springfield to Pueblo, Colorado Hooker to Mocane and Laverne fields, Oklahoma

Here's dragshovel performance that helps keep trenching on schedule

Shown here are three of five Bucyrus-Erie 22-B dragshovels at work laying a 24-in. gas line across Pennsylvania.

Bonus Quality *saves you money*

Bonus Quality This laboratory technician is measuring the carbon content of a piece of steel . . . just one of the many tests given all steel at Bucyrus-Erie. Such testing helps insure Bonus Quality that saves you money — in operating and maintenance costs, as well as in longer service life.

When you equip an experienced pipeline crew with Bucyrus-Erie dragshovels, you've got a combination that keeps trenching and backfilling on schedule. No one knows this better than the men in the field, for they have seen these Bucyrus-Erie advantages at work —

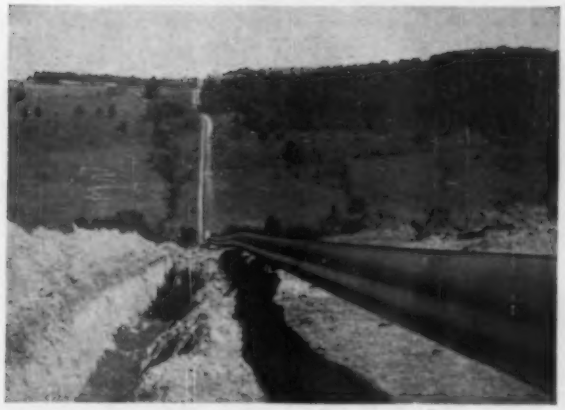
There's high speed on the hoist and swing, as well as full power on the digging stroke for those heaped, quick-filling loads. The cambered mid-section of the boom provides added clearance for digging deep trenches . . . makes dumping easy because dipper can be raised high and brought in close without spilling the load. The dipper has sloping sides, side cutters with straight edges, and extended lip area for clean loading and dumping.

Tractor-type crawlers are available, too, for top mobility. They raise ground clearance enough to permit travel over most obstructions normally encountered . . . provide added traction for climbing grades as steep as 30 per cent where footing is adequate.

See your Bucyrus-Erie distributor soon for the complete story on ½-yd. 15-B and ¾-yd. 22-B dragshovels . . . and give your crews the kind of equipment they need to keep pipe lines moving on schedule. 238E56

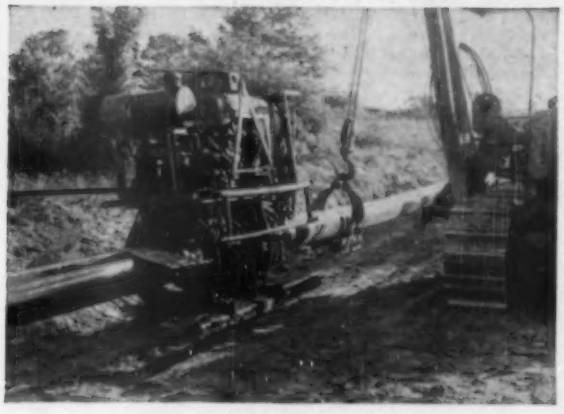
BUCYRUS ERIE

SOUTH MILWAUKEE, WISCONSIN



Pipeline laid over rugged terrain.

Pipeline ditch cuts through shale and rock.



Cleaning machine and primer application.

NO-OX-ID and wrapper applied by Traveliner.

NO-OX-ID COMBINATIONS FOR LONG-TERM PIPELINE PROTECTION

Before you specify the protection you want on your next pipeline job, check into the advantages of Dearborn's NO-OX-ID Coating Combinations. They're your assurance of dependable, long-term protection. Your Dearborn Pipeline Engineer, a specialist in corrosion control, will consult with you and recommend the combination best suited to your requirements.

Investigate Dearborn's New Pipeline Enamel 240

The NEW Dearborn Pipeline Enamel 240 fills the need for a truly economical, long-lasting pipe coating. Made from selected asphaltic crudes, 240 is unusually flexible over a wide temperature range. It features all desirable characteristics with respect to ease of application, dielectric strength, flexibility, penetration, electrical resistance, and minimum moisture absorption. In actual tests, sample strips of 240 have been bent double at 50° F. over a one-inch mandrel without fracture.

ADVANTAGES OF NO-OX-ID PROTECTIVE COATINGS

- ★ Applied hot or cold
- ★ By hand, by Traveliner or at the mill
- ★ No noxious fumes
- ★ Requires less equipment
- ★ Lasts longer

It pays to specify

Dearborn NO-OX-ID®

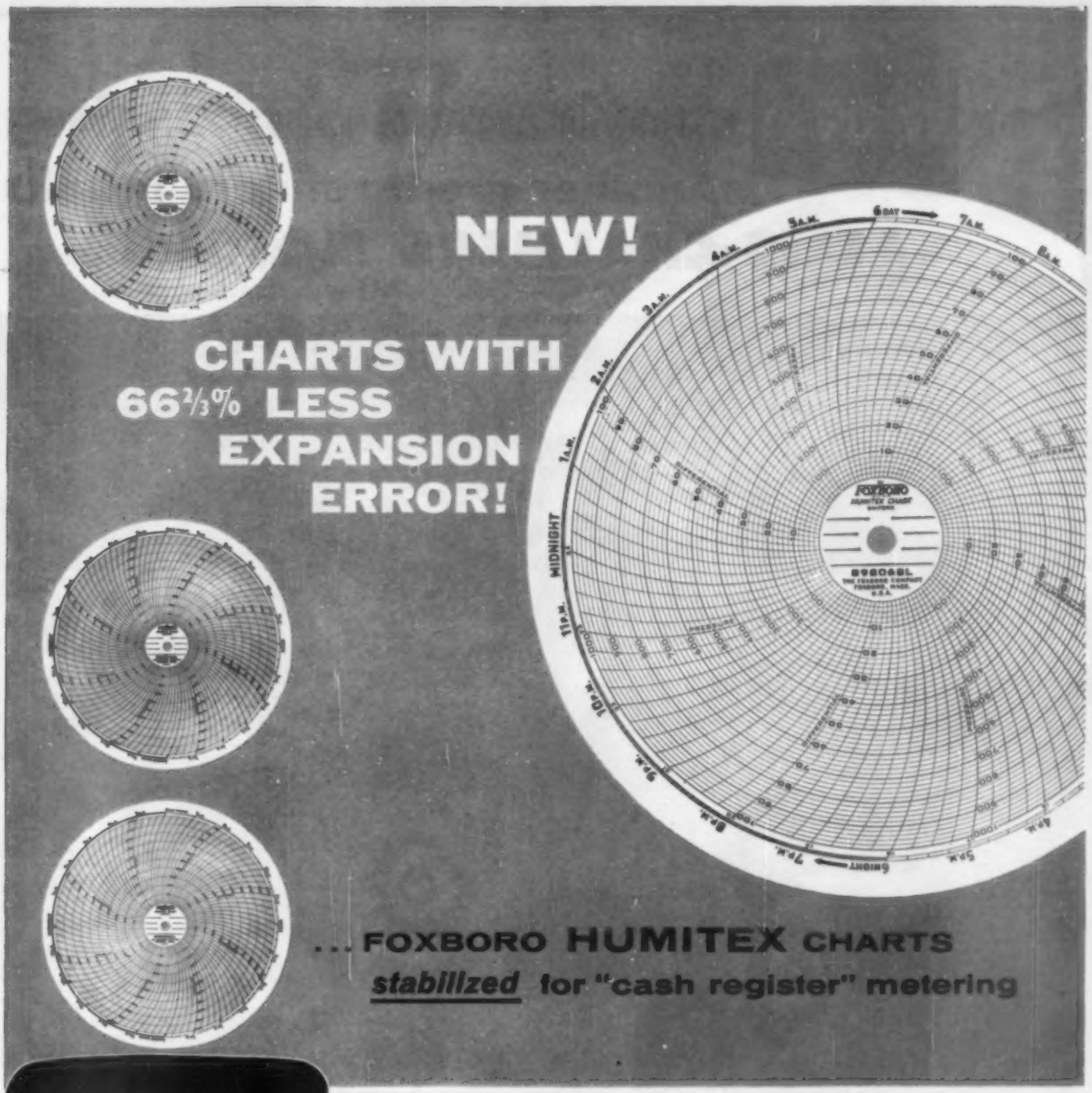
For Long-Term Pipeline Protection

WRITE FOR BULLETIN

"Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers" tells the story. Your copy is ready upon request.

DEARBORN CHEMICAL COMPANY • Merchandise Mart Plaza • Chicago 54, Ill.

Name of Company	Miles	Size	Location
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	20	Loop from Fourway, Texas, to Springfield, Colorado
	106	24	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	48.0	4–16	Additions in Mocane field, Oklahoma
	12.0	12–22	Additions in Texas Panhandle fields
El Paso Natural Gas Company El Paso, Texas	83.8	34	Loops to San Juan mainline extending from San Juan County, New Mexico, to Topock, Arizona
	20.5	30	Loops to existing Permian-San Juan mainline from Bluewater station to San Juan mainline in McKinley County, New Mexico
	8.3	26	Loops to California mainline in Yuma County, Arizona
	28.5	30	Field transmission line in San Juan Basin, New Mexico
	78.8	18	Field line from Carson County, Texas, to Moore County, Texas
	16.0	20	Line from South Andrews field, Andrews County, Texas, to existing Goldsmith Plant
Houston Texas Gas & Oil Company Houston, Texas	28.1	10¾	From Nolan County, Texas, to Jameson field, Coke County, Texas
	961	12-30	Baton Rouge, Louisiana, to Miami, Florida, laterals
Kansas-Nebraska Natural Gas Company, Inc. Hastings, Nebraska	10	10	Grand Island to Fullerton, Nebraska
	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Lone Star Gas Company Dallas, Texas	230	—	Cotton County, Oklahoma, to Fritch, Texas
	205	—	Snyder, Texas to Cotton-Fritch line
Michigan Wisconsin Pipe Line Company Detroit, Michigan	24	24	Looping in Wisconsin
	31	4-6	Looping in Michigan and Indiana
Midwestern Gas Transmission Company	1112	12–24	Mainline from U. S.-Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
	648	3–18	Laterals of mainline to serve communities in Minnesota, North Dakota and Wisconsin
Natural Gas Pipeline Company of America Chicago, Illinois	349	20–26	Jack and Wise counties to Fritch, Texas
	38	36	Joliet to Elgin, Illinois
	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduna field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
Northern Natural Gas Company Omaha, Nebraska	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota, and Superior, Wisconsin
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa and Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company) Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Offshore Gathering Company Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric Company San Francisco, California	83	12–20	Glenn County to Sacramento, California
	200	12	Glenn and Tehama counties to Eureka and Arcata, California
Pacific Lighting Gas Supply Company Los Angeles, California	80	30	Coles Levee to Newhall
	2.1	16–20	Potrero to Newhall
	2.8	16	Lines in East Whittier
Southern Counties Gas Company Southern California Gas Company Los Angeles, California	241	30	Newhall to Topock, Arizona
Tennessee Gas Transmission Company Houston, Texas	100	—	New gathering lines in Texas and Louisiana
	557	30	Mississippi River Delta south of New Orleans to Portland, Tennessee
	120	12,20,26	Kinder, Louisiana, south 68 miles into Gulf of Mexico
	332	24–30	Loops in Kentucky, West Virginia, Pennsylvania, Tennessee
	76	24	Coudersport, Pennsylvania, to Buffalo, New York
Texas Eastern Transmission Corporation Shreveport, Louisiana	530	30	Loops from Kosciusko, Mississippi, to Uniontown, Pennsylvania
	45	24	Provident City, Texas, to McAllen-Vidor line near Blessing
	422	30	McAllen to Vidor, Texas
	141	Var.	Supply laterals from South Texas area to McAllen-Vidor line
	10	12	Loop from Broadaxe Junction to Levick Street, Philadelphia, Pennsylvania
	6	12	Loop from Broadaxe Junction to Conshohocken, Pennsylvania
	5	10	South Plainfield to Highland Park, New Jersey
Texas Gas Transmission Corporation Owensboro, Kentucky	13	20	Assumption Parish to Thibodaux Area, Lafourche Parish
Texas-Illinois Natural Gas Pipeline Company Chicago, Illinois	59	20	Joliet to Volo, Illinois
Trans-Canada Pipe Lines, Ltd. Calgary, Alberta, Canada	1675	30–34	Winnipeg to Montreal and laterals
Trans-Carolina Pipe Line Corporation Raleigh, North Carolina	840	2–18	New line between Moore, South Carolina, and Morse, North Carolina with laterals
Transcontinental Gas Pipe Line Corporation Houston, Texas	251	24,30,36	Loops on system



Like standard Foxboro Humitex Charts, these new *stabilized* charts have extra-high legibility too. Easy-to-read gray printing against the chart's smooth, white background brings out the full brilliance of Foxboro Recording Inks.

Here are the charts specifically designed to meet the high-accuracy requirements of "cash register" metering . . . Foxboro *stabilized* Humitex Charts. These advanced charts feature plastic-laminated paper — assure you *real* dimensional stability under the widest variations in temperature and humidity. In an extensive series of laboratory and field tests, Foxboro *stabilized* Humitex Charts were found to have only ¼ to ⅓ as much dimensional error as the highest grade of standard charts!

Foxboro *stabilized* Humitex Charts are your assurance of consistent, high-fidelity records — wherever you meter — wherever you compute. Try them at our expense. Write for samples and quotation. The Foxboro Company, 3812 Norfolk St., Foxboro, Mass., U.S.A.

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FOR MORE ACCURATE RECORDS **FOXBORO**

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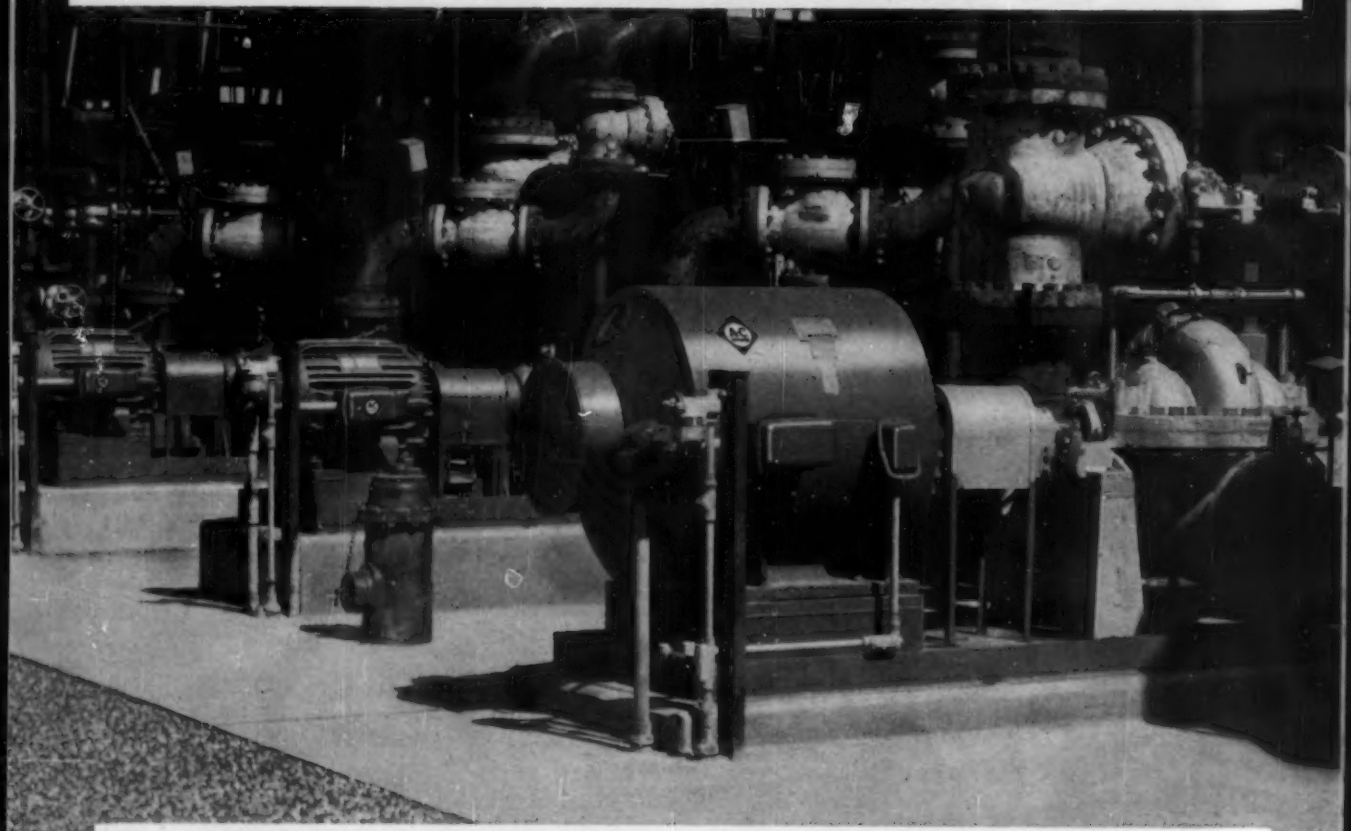
for more continuous processing—

Another great refinery installs

ALLIS-CHALMERS MOTORS



Thousands of horsepower in Allis-Chalmers motors will drive processing equipment at Tidewater Oil Company's new Flying A Refinery, near Delaware City, Delaware.

Designed and constructed by C. F. Braun & Co., consulting engineers and contractors, this plant will process 130,000 bbl of crude oil per day. The largest ever built in a single construction operation, this huge refinery joins a growing list of major petroleum plants in which Allis-Chalmers equipment is used. Main reason for this trend:

Continuous Operation

● **Ribbed Construction** of smaller motors gives up to 43% more cooling surface when compared with ordinary motors. *Tube-Cooled* design in larger sizes permits free flow of air. BOTH designs result in fewer winding burnouts.

● **Motors** are of the chemical type, designed for use in refinery operations.

● **Stators** receive more than the usual dips and bakes. They get extra dips and bakes plus two coatings of red enamel to provide maximum electrical life.

* * *

FIND OUT MORE about Allis-Chalmers motors for the petroleum industry. Contact your nearby A-C sales office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5185

No problems here !

Excellent weldability, plus uniformity in diameter, concentricity and end finish, make Kaiser Steel Line Pipe easy to weld in the field.

This means more pipe can be laid per day.

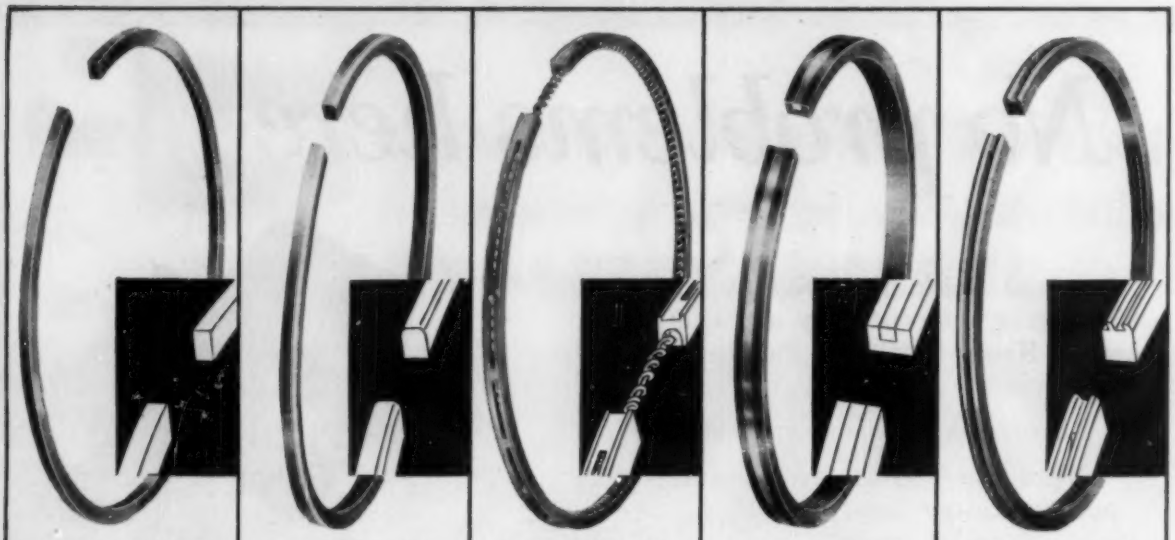
Next time you are ordering line pipe, specify Kaiser Steel Line Pipe.

Rely on Kaiser Steel quality and service to add dollars to your operating profits.

Kaiser Steel

VISUAL WELD INSPECTION ON PACIFIC NORTHWEST PIPELINE.

Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes semi-finished steels • pig iron • ingot molds • coke by-products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • **Los Angeles** • **Oakland** • **Seattle** • **Portland** • **Phoenix** • **Denver** • **Tulsa** • **New York**



COMPRESSION RING . . . 1-piece, quick-seating. Maximum strength. Turned finish on outside diameter lets ring conform readily to the cylinder bore. The chemically treated surfaces aid rapid seating, no scuffing or scoring during run-in. ½″ to 120″ diameters.

POROUS CHROME PLATED RING . . . exclusive Van der Horst process. Shallow porosity on cylinder contacting surface facilitates break-in, holds and distributes oil during this critical period. Lasts four times longer, cuts cylinder wear up to 75%. ½″ to 42″ diameters.

CONFORMABLE OIL RING . . . maintains constant pressure for positive oil control. Conforms to meet cylinder distortion; flexible cast iron member, pressed outward by abutment type spring exerts uniform radial pressure around entire circumference. 4″ to 25″ diameters, ¼″ min. width.

KOPPERS SEAL RING . . . has one or two projecting bands of bearing bronze inserted in contacting face. Very quick-seating. Tends to prevent blow-by in new or worn cylinders. The burnishing action of bronze on cylinder walls decreases scuffing and wear. 2″ to 30″ diameters.

GROOVED OIL CUTTER RING...valuable where oil control is a major problem. Two bevels for riding over oil on up-stroke, two scraping edges for removing excess oil from walls on downstroke, plus a series of wide drainage slots. 1½″ to 25″ diameters.

Five Koppers Rings . . . worth their weight in gold!

What will American Hammered Industrial Piston Rings *do for you?* They'll save you money on fuel, on lubricating oil, on labor costs—by reducing down-time.

They'll maintain high compression, improve your operation, give you *much* longer service. They don't cost much . . . but they have over 35 years of manufacturing skill and accumulated experience behind them. They never let you down, they never fail in the jobs they're designed to do—and hundreds of satisfied users will tell you that, despite their low cost, Koppers rings *are* worth their weight in gold.

American Hammered Piston Rings are available in all types, all sizes—from ½″ to 10′ diameter—for every purpose. Koppers makes American Hammered Rings for all kinds of industrial equipment, can recommend without bias as to types. It costs nothing to consult Koppers—for illustrated Piston Ring booklet write to KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.,* 1712 Hamburg Street, Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore 3, Maryland
This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus.
Engineered Products Sold with *Service*

KOPPERS®

AMERICAN HAMMERED
Industrial Piston Rings

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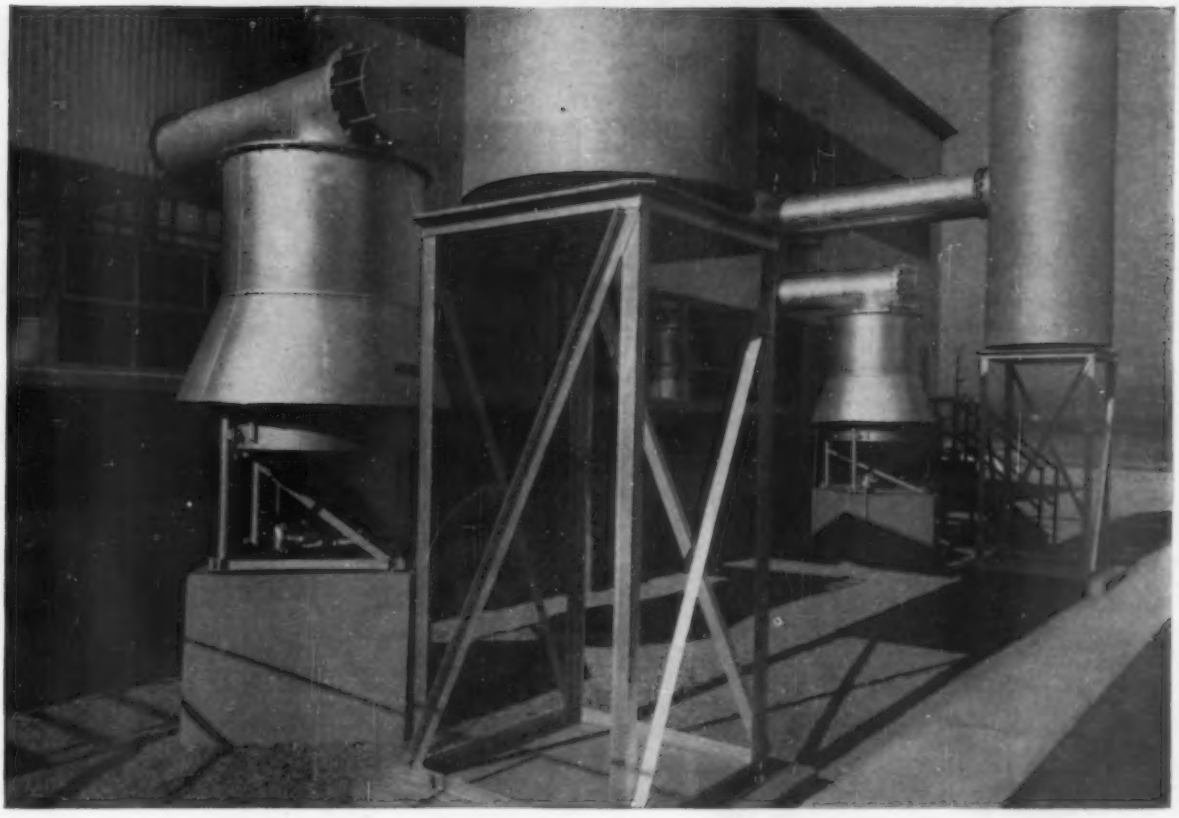


AAF Cycoils Type "P" protect Cooper-Bessemer engines from costly dust trouble at Sugar Grove, Ohio pumping station of Ohio Fuel Gas Company.

CYCOILS tell a *Sweet Story* at Sugar Grove

Ohio Fuel Gas Company is mighty particular about its machinery and equipment. They have to be. The big Cooper-Bessemer engines in this pumping station at Sugar Grove, Ohio, for instance, are the heart of the area's fuel gas supply. Dirty air could cause real damage.

What better reason for those AAF Cycoils Type "P" . . . protecting vital equipment, assuring uninterrupted flow of gas! Type "P" Cycoil utilizes a new principle in oil bath air filters—a perforated entrainment plate, placed in the air stream. Oil flows over the plate from a central distributing head. Metered orifices in the plate are calibrated to increase velocity of air flow through the openings to entrain the oil that tends to spill over the edges, and distribute air flow uniformly over the area. Entrainment accomplished, air then passes upward through primary and secondary filters for removal of dust and oil content. Result is air that's virtually 100% *dust-free!*

Here's the kind of protection your engines and compressors need. Protection that saves money, blocks trouble. You get it only with AAF Cycoil Type "P". So get the facts. Write for Bulletin 160.

Type CMS Multi-Duty Filters

Type G Pipeline Air Filters

American Air Filter
COMPANY, INC.
384 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

BETTER AIR IS OUR BUSINESS

Type OCH Intake Air Filters

Cycoil Oil Bath Air Filters

Maintenance engineering

You can arrange to have a Honeywell service engineer visit your plant at regular intervals to inspect, clean, and adjust your instruments and controls. He's factory-trained and field-experienced in keeping good instruments in top operating condition. If an emergency should arise, a phone call will bring a Honeywell service engineer to your plant in a hurry.

Spare parts, in a rush

A Honeywell branch office near you can be your storeroom for standard parts . . . in addition, the Parts Depot in Philadelphia carries a complete stock of all normally needed parts. With Honeywell stocking your spare parts, you save storage and inventory control costs. Most shipments are made within 24 hours after orders are received.

Application engineering

Experienced Honeywell application engineers know your industry and processes. They design *complete* systems of instrumentation, reducing the work of your own engineering staff. From the broad Honeywell line, they recommend instruments that are exactly right for the job. And because Honeywell supplies all types of instruments, recommendations are made without bias. Service engineers will, if needed, help with installation and startup of your system.

Service is the big extra you get with Honeywell instrumentation

Practical service training

The tuition-free Honeywell Training School teaches your instrument technicians the most up-to-date maintenance methods, fits them for the kind of problems they may encounter on the job. Intensive courses range from two to fourteen weeks.

Honeywell offers you far more than instruments. You get service whenever and wherever you need it . . . service that begins when you first decide you need instruments, and continues long after they're installed. This service is always conveniently close at hand, for there are more than 110 Honeywell sales and service centers located strategically throughout the U. S. and Canada.

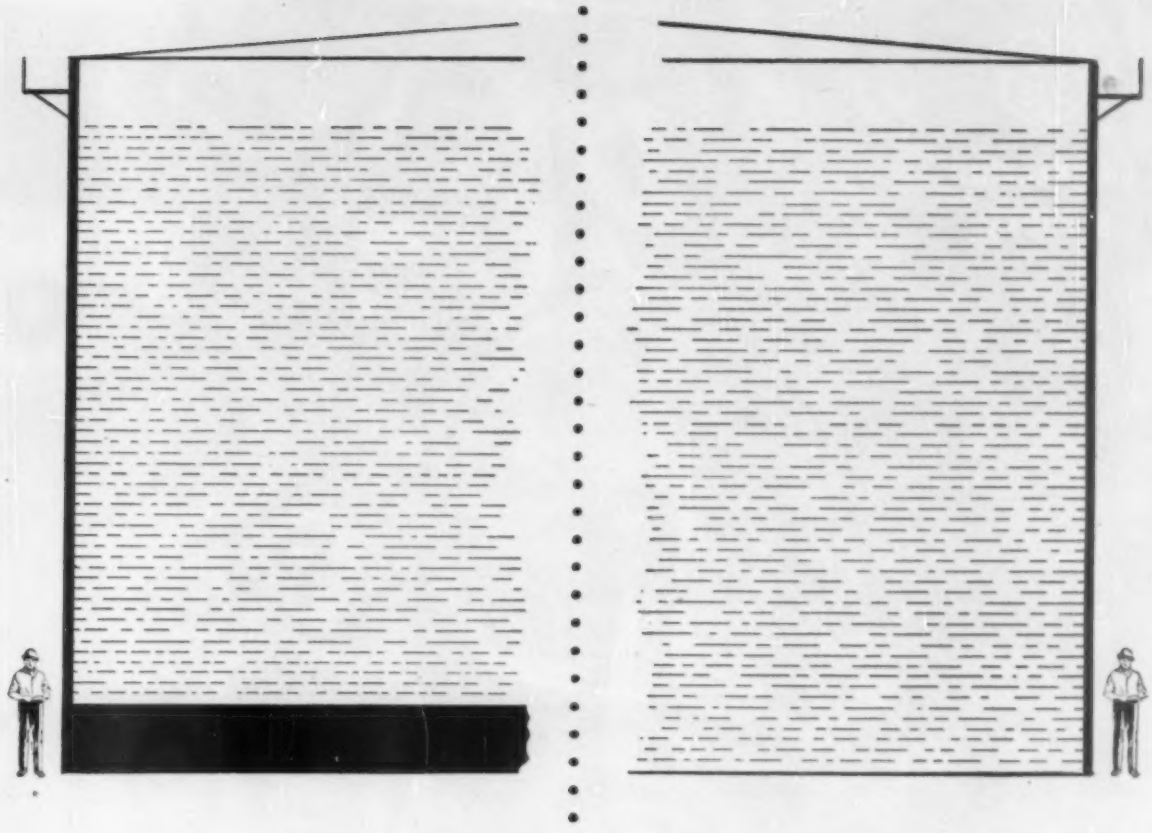
Prompt, competent service by nearby field specialists is an important plus-value of Honeywell instrumentation. Your local Honeywell sales engineer has all the facts on this service as it relates to your instrumentation needs. Give him a call . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls



Which tank has the Lightnin Mixer?

Also, which tank looks like *yours?*

In the crude storage tank on the left, a three-foot buildup of bottom sediment is using up 5% of the tank's holding capacity.

Before long, this tank will be out of service for cleaning—another dead loss of 3½ to 5% in working capacity.

Cleaning out the sludge costs money, too. And you usually throw out merchantable material *with* the sludge.

How to stop sludge buildup

The tank on the right shows what happens when you install a propeller-type LIGHTNIN Mixer. The mixer propeller turns over the entire tank contents gently and thoroughly—holds paraffin and other heavy components off the tank bottom and keeps them dispersed uniformly. The stream leaving the tank contains the same values that entered the tank.

Results? No more costly downtime for cleaning your tanks. Full tank storage capacity always available. You eliminate the expense and mess of tank cleaning. You realize full value on *all* components of the crude you handle.

Here's how little it costs

You can stop sludge losses in any tank—permanently—for roughly the cost of *a single tank cleanout!* This is why so many pipe line companies find LIGHTNIN Mixers a profitable way to boost tank-farm efficiency, cut maintenance costs for good.

How much can *you* save? Your LIGHTNIN Mixer representative will be glad to show you, without cost or obligation, just what you gain by installing LIGHTNINs on your tanks. For quick, competent help, phone him today. (He's listed in your copy of Composite Catalog.) Or write us direct.

Lightnin® Mixers™

MIXCO fluid mixing specialists

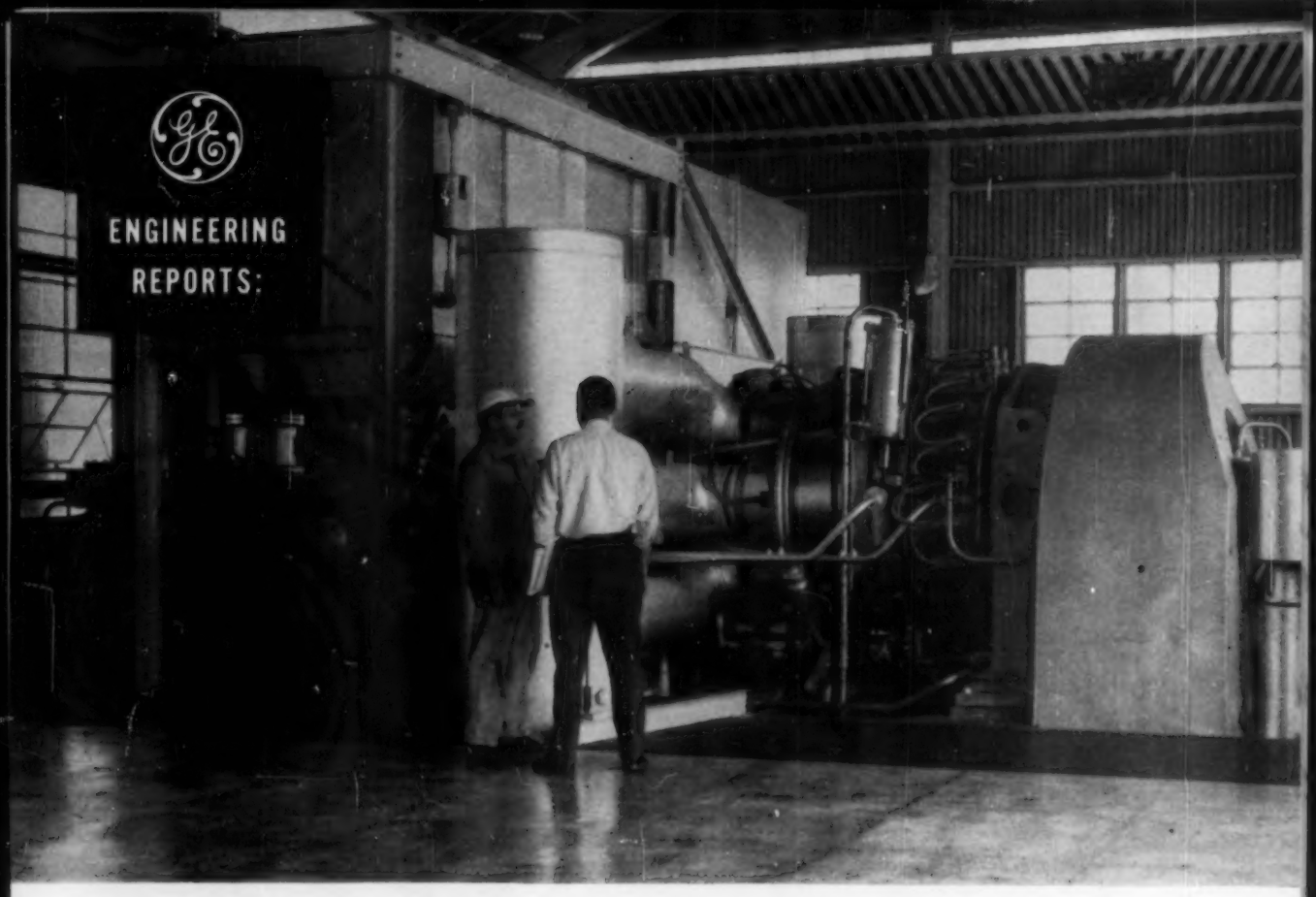
CONTROL SLUDGE in tanks as large as 140,000 bbls. with LIGHTNIN Mixers, guaranteed to do the job right.

Get these helpful bulletins on BS&W control and LIGHTNIN Mixers. Check, tear out and mail to us today with your name and company address. Free—no obligation.

- ☐ B-503 BS&W Control with LIGHTNIN Mixers
- ☐ B-104 Side entering mixers. 1 to 25 HP
- ☐ B-107 Data sheet for figuring mixer requirements
- ☐ B-109 Condensed catalog describing LIGHTNIN Mixers—all types
- ☐ B-111 LIGHTNIN rotary mechanical seals for extra-low-cost mixing

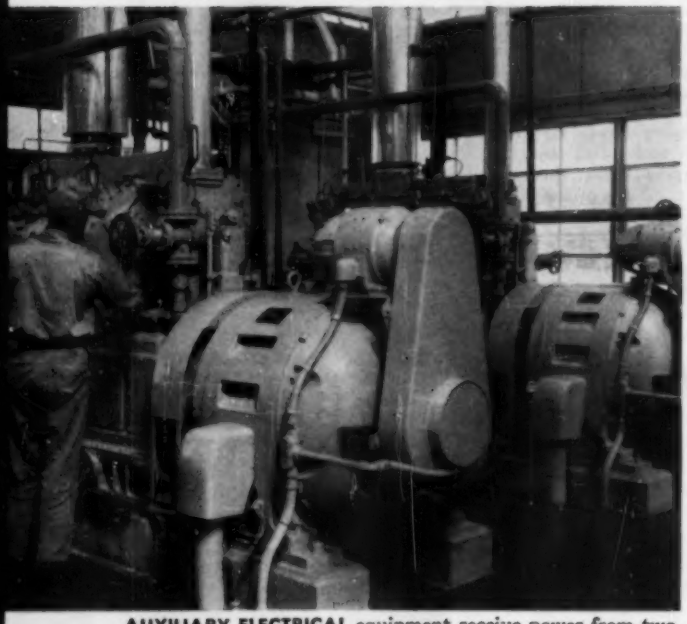
MIXING EQUIPMENT Co., Inc., 127-n Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.



Powered by General Electric engineered drive system . . .

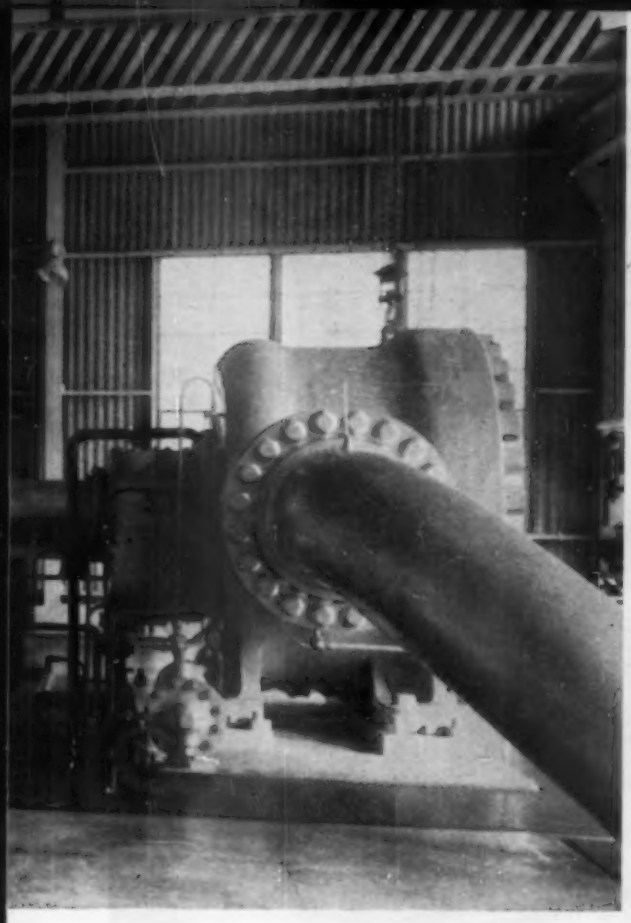
Tennessee Gas Transmission uses parallel



AUXILIARY ELECTRICAL equipment receive power from two General Electric 187-kva, engine-driven, a-c generators which supply 480-volt, 60-cycle power for the station system.

COMPACT, FACTORY ASSEMBLED General Electric Cabinetrol* panel centralizes control of station's auxiliary equipment, was planned to take up minimum valuable floor space.

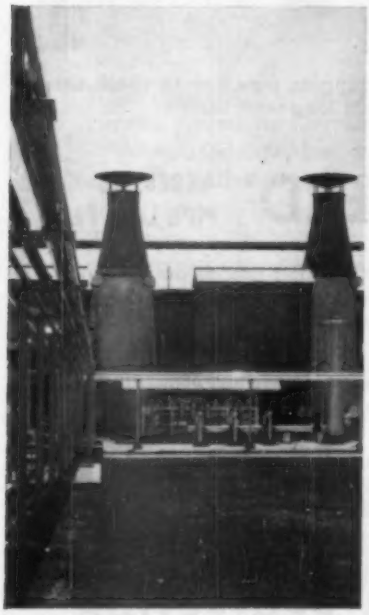
*Reg. trade-mark of General Electric Co.



CENTRALIZED CONTROL for the 2 General Electric gas turbines is located in accessible, duplex control panel. Panel provides semi-automatic operation, requires little supervision.

PARALLEL COMPRESSOR ARRANGEMENT, first in the industry, permits two 6700-hp gas turbines to handle station's prime mover requirements for 4-season, lower cost operation.

compressor arrangement in Morehead station



TURBINE EFFICIENCY is increased with regenerators, located outside new station, that "recapture" exhaust heat.

General Electric engineered compressor drive system, with two 6700-hp gas turbines, helps lower new station's operating costs

The Tennessee Gas Transmission Company's new Morehead, Kentucky, pipeline station has two centrifugal compressors arranged for parallel flow, to provide highly flexible operation. With this arrangement—an industry first—the adjustable speed compressors provide a wide range of flows and piping combinations with high stability.

THE DRIVE SYSTEM was installed to meet the station's individual compression requirements and to help lower operating costs. Speed adjustment of the turbines, to meet seasonal increases in compressor load, is easily accomplished. The station has lower maintenance and operator requirements. In addition, the gas turbine fundamental characteristic of increasing horsepower, with decreasing ambient temperature, means that up to 25% more horsepower is available to meet cold weather's increased load requirements.

WHEN YOU EXPAND your compressor facilities, General Electric has a complete line of engineering services also available to you, to help you and your consultants install a drive system engineered for your particular requirements. Your Apparatus Sales Representative, at the nearest General Electric Apparatus Sales Office, will give you complete information. Contact him early and write for bulletin GEA-5962 to General Electric Co., Section 661-54, Schenectady, N. Y.

Engineered Electrical Systems for Pipeline Pumping

GENERAL ELECTRIC

For effective, long-term protection against corrosion . . .

Close-up of Transhield Asbestos Pipe Line Felt, showing parallel-spaced glass yarns.

Coating and wrapping pipe line to check corrosion and assure long-term service.

. . . use Johns-Manville TRANSHIELD® ASBESTOS PIPE LINE FELT

Johns-Manville Transhield is an economical pipe line felt assuring effective, long-term protection against corrosion under average soil conditions.

Designed for easy, high-speed application by modern machine methods, Transhield is strong and highly tear-resistant. Its light weight permits its use in 800-ft. rolls. This advantage cuts roll changes in half for field wrapping equipment.

Transhield provides a protective membrane of coal-tar saturated asbestos felt, reinforced with continuous glass yarns parallel-spaced on ¼" centers. It cannot rot or decay, thus acts as an enduring barrier to shield pipe line enamels from earth loads and soil stress.

For severe soil conditions use Johns-Manville #15 Asbestos Pipe Line felt . . . proven in service for over 30 years.

For further information about Transhield, write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ont.

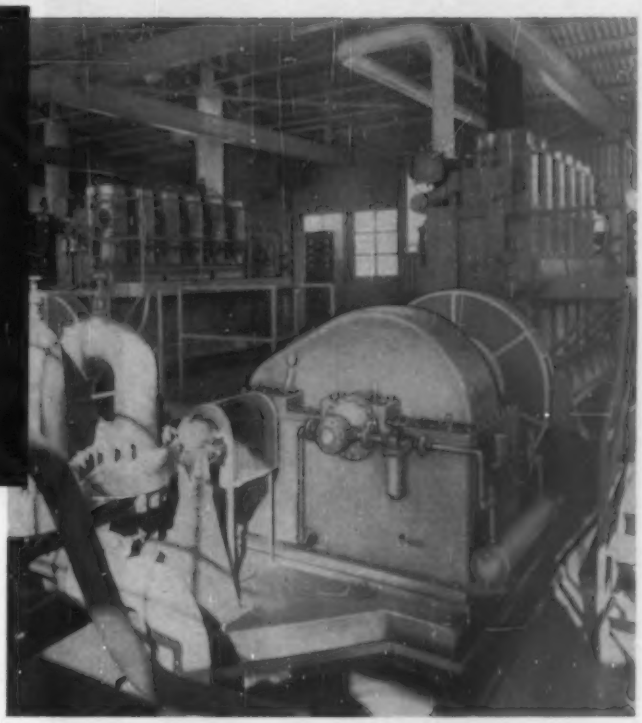
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PRODUCTS FOR PIPE LINE PROTECTION

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Confidence in Western Gear performance!

100 MILE PIPELINE REPLACES TANKER RUN



Ventura station has Western Gear Model 250 HS 90 High Speed unit, rated at 520 HP, driven by 520 HP Enterprise gas engine. Pump is 4-inch United centrifugal four-stage.

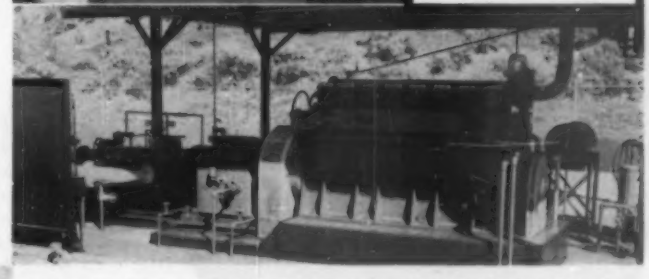
Four Western Gear high speed units were selected by Union Oil for installation in three pumping stations along its recently completed 100-mile pipeline system from the Santa Paula-Ventura fields to the refinery at Wilmington, California. The line now carries crude petroleum which formerly was transported by water in tankers.

The line travels over rugged country and one of the pumping stations was literally carved out of the side of a mountain. Another is completely automatic and unattended. All engines, gears and pumps are equipped with automatic temperature controls and temperature shutdown switches.

When designing and constructing pumping stations, progressive companies usually specify Western Gear speed reducers or high speed units. The unrivaled quality of Western Gear drives has made them the logical selection of the leaders in the petroleum industry. If you are planning on modernizing, replacing old equipment or building new lines, why not call on Western Gear for consultation on your gearing problems?

Address General Offices, Western Gear, P. O. Box 182, Lynwood, California.

Two Western Gear Model 250 HS 130 High Speed units are installed at the Torrey station, driving 4-inch United centrifugal six-stage pumps. Prime movers are 520 HP Enterprise gas engines.

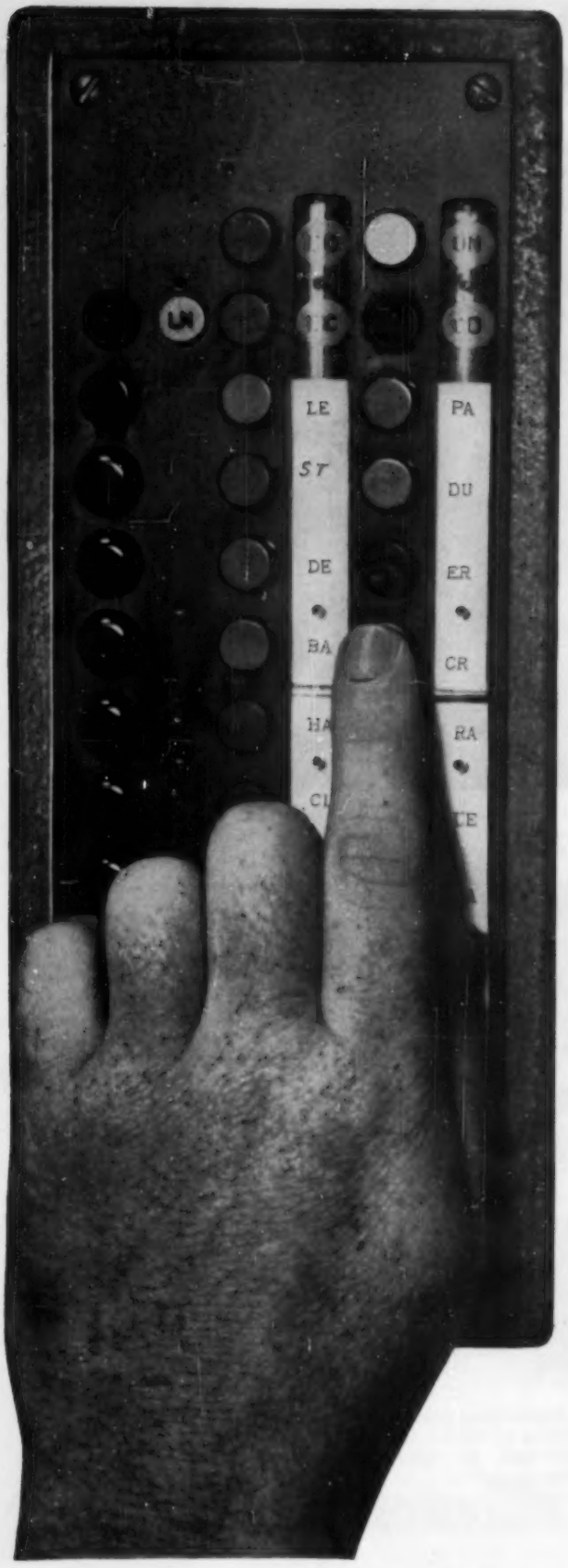


Western Gear 160 HS 90 High Speed unit, is installed at the Piru Union Oil Station. Unit is rated at 360 HP, prime mover is 300 HP Enterprise gas engine. Gear unit drives 4-inch United centrifugal two-stage pump.

"The difference is reliability" • Since 1888 5807

WESTERN GEAR Corporation
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES



Push-button selector speeds coded data in Gulf Interstate's telemetering system

You are looking at a special push-button private line teletypewriter device developed by the Bell System and used by Gulf Interstate Gas Co.

The company uses the teletypewriter as a recorder in its digital telemetering system, which provides automatic transmission of operating data. Such data includes engine speeds as well as suction and discharge pressures at five rèmote compressor stations.

The dispatcher in the company's Houston headquarters simply pushes the proper buttons. The selected distant station is instantly on the circuit. Coded telemetered data is then received directly on the teletypewriter in the form of an accurate, easily read record.

This unique selector unit is another example of how equipment developed by the Bell System meets communication needs.

The Bell System welcomes the opportunity to work with you in a study of your special communication requirements. There's no obligation.

Bell Telephone System

PRIVATE LINE TELEPHONE • PRIVATE LINE TELETYPEWRITER
CHANNELS FOR: DATA TRANSMISSION • TELEMETERING
REMOTE CONTROL • TELEPHOTOGRAPH • CLOSED CIRCUIT TV

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

A Christmas Story

Carl I. Huss
Standard Oil Company (Indiana)

FIRST REPORT ON THE SECRET "NORTH POLE" PIPE LINE!

Santa Meets Some Pipeliners

This Paul Bunyon-type story about pipeliners has nothing to do with reality and the problems of pipeliners, the usual domain of *The Pipeline Engineer*. It is presented as a Christmas treat in the hopes of getting your minds off your pipe line problems for a few minutes.

SANTA CLAUS scratched a patch of frost from his living room window and squinted at the North Pole in his front yard.

He shivered. Yes, the North Pole's shadow was still frozen to the ground. For two months now the mercury had huddled in a tiny ball in the thermometer bulb, too cold to move up the icy tube.

Santa muttered something to himself and turned from the window. For the hundredth time he read the furnace oil gage on the wall and for the hundredth time he frowned. Winter was only half over and already the gage read: "Fuel supply dangerously low!"

Santa's house was below freezing even then, but he turned down the furnace another notch. He frowned, twitched his big red nose turned half blue by the extreme cold, then turned the furnace down still another notch.

Santa was plenty worried. He trudged into his work shop which was as quiet as crude oil moving through a pipe line. His merry band of workers weren't merry at all. And they weren't working. They sat hunched over their work benches, their hands in their pockets.

"What's not going on here?" Santa asked, knowing the answer before he asked.

"Sir," the head elf and Santa's number one swamper replied, "the shop's so cold the workers' fingers are stiff. They can't make dolls and fire engines and cowboy suits for the good boys and girls because they can't hold their tools."

"By Ned! This *is* serious," Santa said. "But I can't turn up the furnace. If I did, we'd soon burn up our last bit of fuel oil, then we'd freeze to death for sure. What's to be done? What can I do?" He frowned even harder and twitched his nose. "Christmas is coming and we won't have the toys ready . . ."

SANTA felt a tug at his red trousers and looked down. There stood Smiley, his most cheerful and faithful worker.

"Why, hello, Smiley," Santa said. "What can I do for you?"

"Please, sir," Smiley said, "may I suggest a possible solution?"

"May you! By Ned, you certainly may," Santa boomed. "I'm open for all suggestions."

"Why don't you send a dogsled-o-gram to the Slim Inch Pipe Line Company in Dallas, Texas, USA?" Smiley said.

"Slim Inch Pipe Line Company? What's that and what can it do?" Santa asked.

"Why it's one of the top pipe line companies in the United States," Smiley replied. "My cousin's a water sprite who lives in a bank of the Trinity River. He's told me all about Slim Inch. He says it's an all-right outfit. I'll bet they can figure some way to get furnace oil up here."

Santa slowly shook his head. "I don't know how they'd get through this weather."

"I don't either," Smiley replied, "but why don't you give them a chance? After all, those American pipeliners have figured out ways to cross mountains and go under deep lakes. I'll bet they could figure out something."

"By Ned, it's worth a try," Santa said. "I'll do it. I'll send a dogsled-o-gram to the president of Slim Inch Pipe Line right away."

He went immediately to his desk and wrote a message outlining his trouble.

By return dogsled-o-gram he received this reply:

'S CLAUS NORTH POLE STOP SLIM INCH BOARD OF DIRECTORS MET AND DECIDED TO LAY A PIPE LINE TO YOUR HOME STOP PIPE LINE WILL ELIMINATE FUTURE PROBLEMS BY ASSURING YOU CONSTANT STEADY SUPPLY OF FUEL OIL STOP WORK STARTS IMMEDIATELY.

SLIM Inch meant immediately, too! By the time Santa got the message, Slim Inch right-of-way men were tromping across the frozen wastes on snowshoes. They had to revise their method of buying right-of-way, however, they paid so much a ton instead of the usual rod measurement.

The resourceful pipeliners buzzed with plans and ideas. They would make ditch with a snow plow, they decided, and string the pipe from giant sleds drawn by reindeer and moose (extra rope and chain could be wound around the animal's horns.)

Hardly underway, they hit their first snag.

Welders tried to weld joints of pipe together, but the flame froze to the end of their torches. They broke off the flames and thawed them out in skillets of hot grease. Yet, by the time they got the thawed-out flame back to the pipe it had frozen again.

A "reindeer skinner" finally solved the problem by doing away with welding altogether. He suggested they line up the joints and pour scalding water on them. They did. The water froze immediately, forming an unbreakable weld. Construction went on.

Coating and wrapping material wasn't needed. However, because of the sub-zero weather, the engineers figured they'd better apply a coating warm enough to keep the furnace oil from freezing in the line. They sewed together woolen pants legs in one continuous strip. They slipped this woolen sheath over the pipe line like you'd put on your socks.

By watching a hungry polar bear scratch for food, an observant pipeliner discovered an easy way to backfill the line.

He dropped salted mackerel in the piled up snow beside the ditch. Sure enough as soon as the gang moved on up the line the polar bears started digging for the mackerel. In the process of scratching for the fish the bears covered up the pipe in the ditch.

Ordinarily, they might have continued digging until they damaged the pipe. However, the salt made them so thirsty that they soon left the site in search of thirst-quenching water.

During the seventh week of construction the crew came upon a towering glacier. It was too large to go around, and too tall to go over.

Dynamite was the only answer. The powder monkey ice-picked holes in the glacier and set large charges of dynamite.

Blooie! roared the dynamite. Up, up sailed the blasted ice high in the air. The men rubbed their eyes in astonishment. The shattered ice didn't fall to the ground. It froze in mid-air.

But it was up out of their way, so the pipeliners moved on with their pipe laying.

DISASTER struck hard two days later. Without warning a wicked williwaw, a wind more powerful than 20 Kansas tornadoes, blew up. It swept everything before it.

It blew into the open end of the pipe that was already laid, inflating the pipe like a balloon.

Fighting against the fierce wind, the pipeliners stuffed ice into the open end of the pipe. Finally they got the opening closed against the powerful force of the williwaw. Even so, there lay two miles of the inflated line with a diameter as big as a railroad tank car.

"It it works one way it'll work the other," growled the spread foreman.

He directed the pipeliners to cut the pipe just beyond the inflated area. They did and left the end exposed to the raging wind.

"Now, we'll let Mr. Williwaw work for us," the foreman said.

Since the wind was now blowing across the opposite end of the pipe, it

sucked the inflated pipe back to its normal size.

As suddenly as it came the williwaw blew away. The dog-tired pipeliners hurried to the cook shack for a hot cup of coffee.

But there was no cook shack! Only the fat cook remained. He sat on an empty potato crate, his white apron hanging in shreds about him.

"Lucky for you guys I am so fat or I would have been blown away, too," the cook smirked.

"Yeah!" a hungry moose skinner taunted, "what good is a cook without anything to cook?"

Pipeliners aren't the martyr type. They went back to their pipelaying without a whimper. But even a pipeliner can take only so much. Exhausted, the men fell beside their noble effort, the pipe line, to die. Numbness crept over them. They felt the icy hands of death taking their pulses.

All was lost: The pipeliners, Santa Claus and his helpers, and all the happy Christmases to come.

Faintly, ever so faintly, strange voices penetrated the dying pipeliners' consciousness. They used their last bit of will power to lift their eyelids a fraction. They saw men and women—or women and men; they couldn't tell which—clad in furs. Eskimos!

Quickly the Eskimos wrapped the frozen pipeliners in furs and fed them big helpings of Eskimo Pies.

A rugged bunch, the pipeliners soon regained their strength and were laying pipe the fourth day after the Eskimos found them. As for the Eskimos, they made sure the pipeliners had a larder full of Eskimo Pies and whale blubber before they left.

With that kind of chow facing them, the pipeliners really wanted to reach Santa's home. They speeded up the work.

EARLY one morning about a month later, a ditching-machine operator glimpsed a large house with a peppermint-striped roof in the distance.

"Hey look!" he shouted. "We've made it!"

The pipeliners let out a yippee that shook the North Pole.

Meanwhile, Santa and his gloomy helpers sat in their cold house, wondering how much longer they could hold on. Their last drop of fuel oil burned three days ago. They hadn't eaten a hot meal since. They huddled together in their warmest clothing, waiting for the end.

"By Ned!" Santa said. "Did I hear a cheer?"

They all rushed to the windows to see.

"Look!" Smiley shouted. "It's those Slim Inch fellows. I knew they'd make it somehow. I knew they'd make it."

"By Ned," Santa grinned. "By Ned. Your suggestion sure saved our frostbitten skins, Smiley. And I do mean frost-bitten."

Turning to the other workers Santa said, "Let's all go out to meet them."

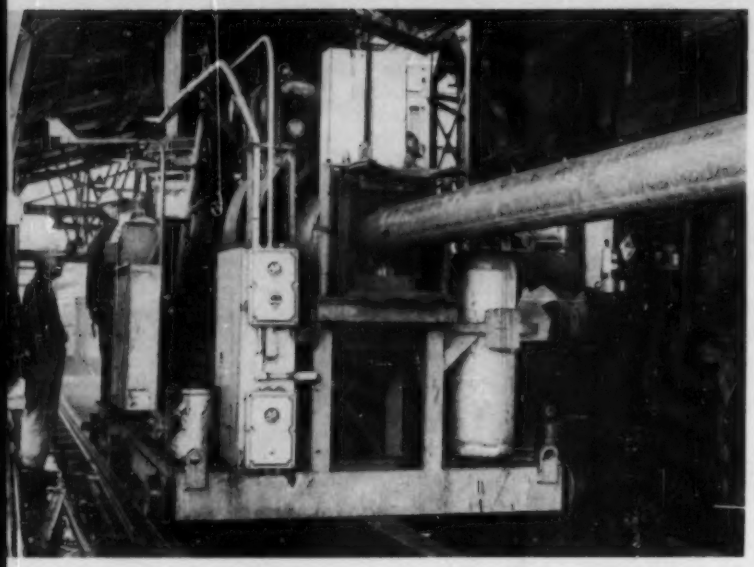
"Let's do!" the workers shouted. They scurried about like school children and soon were plowing through the snow toward the advancing pipeliners.

Fat Santa chugged along after the elves, huffing and puffing. When he reached the pipeliners he stood panting.

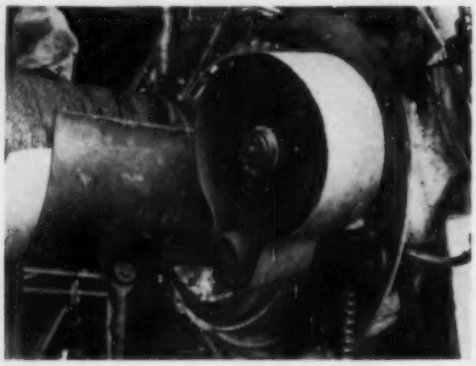
"Welcome . . . to . . . the . . . North Pole . . . gentle . . . men," Santa finally gasped. He waited a long while, then continued: "Your valiant deed will go down in history as one of the most unselfish acts ever performed. Your accomplishment will gladden the hearts of millions of boys and girls all over the world. We will now be able to speed up our toy production because of the furnace oil your pipe line will bring us. We, and the millions of boys and girls all over the world, salute all pipeliners everywhere, especially the Slim Inch pipeliners. I thank you."

A rousing cheer split the frosty air, and suddenly the North Pole was a warmer place. And if you were looking closely you might have seen the North Pole's shadow move just a wee bit. ★ ★ ★

Dual-Purpose Marine Coating



The coating machine that extrudes hot asphalt mastic onto the pipe. The pipe is flame cleaned, then brush cleaned and coated; no primer is required. Weight of the coating material can be increased up to 240-lb per cu ft.



Coming out of the coating machine, the pipe receives an outer wrap of heavy duty fiber glass.

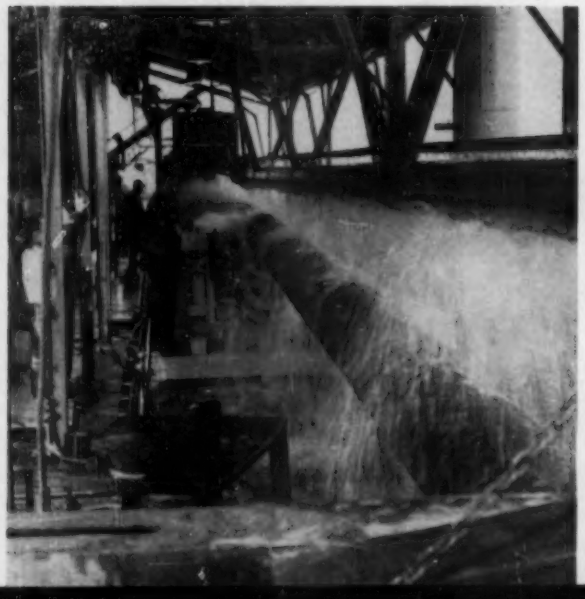
FIRST large scale application of Southern Production Company's dual-purpose coating for submarine pipe lines was made in late October and November on 27 miles of 12-in. line and 3800 ft of 8-in. line in South Louisiana. This coating which is designed to provide negative bouyancy and corrosion protection, too, was extruded onto the line as it was "stove-piped" from a lay barge into the water.

Brown and Root laid the line for Southern Natural Gas Company. It runs from the Lake Enfermer field to the company's Barataria line. The pipe was coated continuously as it was welded joint-by-joint from an assembly of barges. The asphalt coating mixture was dry-batched at a shore installation and transported to the coating barge in the "marine spread" as it was needed.

This new coating which has been named "Timcoat" by its developers has a rubberized asphalt base. At the aggregate barge the finely ground rubberized asphalt is mixed with barite, sand, and limestone. This mixture is then transported to the coating barge where ¼-in. fiber glass slivers and asphalt emulsion are added to it as the mixture is brought to the proper temperature for coating.

The pipe, which has been welded and X-rayed on preceding barge units, is heated and cleaned just before it enters the special coating machine. The asphalt mastic is extruded onto the pipe

Before the pipe goes onto the rollers ahead of the overbend into the water, the coating is water cooled to give it strength. This cooling of the coating while in a semi-plastic state gives added bond.



Into the water, goes the pipe on Southern Natural's 27-mile 12-in. line. The ductile coating has given no evidence of cracking or checking on this job.

Gets Its First Big Test

Dense asphalt mastic was used to provide negative buoyancy and corrosion protection on a South Louisiana pipe line

under high pressure and as it leaves the extruder it receives a tight outer wrap of heavy duty fiber glass. Next, the coating is flooded with cool water to set it.

The density of the coating can be controlled through the addition of the sand and the barites. Weights up to 240 lb per cu ft have been achieved through the latter.

The developers of the coating are delighted with the preliminary corrosion surveys, claiming that a normal coating thickness of 3/32-in. would serve to protect the pipe under normal conditions. However, the increased thickness of the coating (1¼-in. for the 8-in. line; 1-in. for the 12-in. line) multiplies the coating's protective values.

One of the chief advantages cited for the coating is its initial ductility which permits the pipe to be deformed to any degree within the elastic limit of the steel itself without cracking or checking the coating.

How the Line Was Laid and Coated

Brown and Root used five barges in this pipe line spread. The first unit is a stalking barge. On it, a supply of pipe is maintained. A crane on the stalking barge transfers the joints of pipe to the lay barge immediately behind it. On the next two barges there are two welding stations and one X-ray station. At the first welding station, the line-up, stringer-bead and hot-pass are made. At the second station, the weld is completed, and at the third station it is X-rayed.

The fourth barge in the hook-up is the coating barge which contains cleaning, coating and cooling equipment. The last barge in the spread is a materials transfer barge that carries the dry mixture of the asphalt mastic.

The figrst step on the coating barge is to flame clean the pipe. This improves the bonding of the coating to the pipe. Next, the pipe is conventionally cleaned by rotating brushes and then it enters the extruding machine.

The heated mastic is precision-extruded onto the pipe, and as the pipe leaves the machine it is given a double outer wrap of glass. Next, a high volume water spray cools the coating before it contacts the rollers that support the line ahead of its overbend into the water.

The contractor was very careful to catch all faulty welds at the X-ray station because coating is difficult to remove once it has been applied. In the laying thus far, only two welds have been cut out once they were coated.

Logistics. Ordinarily the naked pipe is transported to the forward end of the laying barges and the dry-batch mixes of the asphalt coating to the after end. However, when traversing any canal the supply routes must necessarily change and sometimes it is necessary to string the pipe along-side the canal prior to the laying operation.

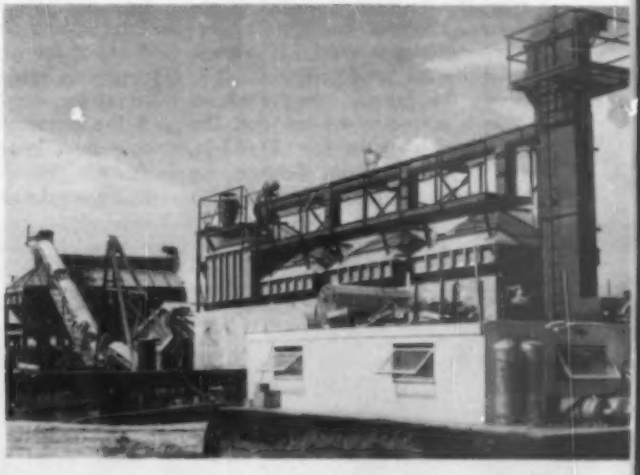
Tie-ins. The tie-in operation is similar to that of conventionally concrete coated lines. After the weld is made, the two shoulders of the asphalt weight coating are bridged by a metal form and the asphalt mastic is vibrated around the pipe. When the annulus is full and compact, the metal form is closed and banded together and the pipe is lowered into the water.

Some of the advantages of the coating. The greatest advantage according to the developers is that the coating remains on the pipe during the laying operation. Moreover, there are no cracks to permit the entrance of water to the underside of the coating.

So far as electrical resistance is concerned, the thick coating which is made from de-salted asphalt holds great promise. The void space is held to a minimum by the progressive grading of the size of the components of the dry batch, and this inhibits the invasion of water. The electrical resistance of the coating seemingly follows that of the other asphalt coatings now in use, although the increased thickness of the underwater coating greatly increases the overall resistivity.

One of the most impressive things about the coating so far as the average pipeliner is concerned is its bond to the pipe. Even when an ax or an air-hammer is used to remove the coating, it will not flake or chunk off the pipe.

Front of the lay barge shows conventional "stove-pipe" operations. The first two stations are for welding; the third for X-raying.



Dry aggregate on the way to the coating job.

Field Adjustment Saves Money

. . . and Time, Too

Gas compressors modified for operation at pressures in excess of design

1 The tools and drill jig are laid near the cylinder. One vertical piston drill and a taper adapter, chuck, and tap. One Keller "Airfeedrill"® and a drill bushing tip and drill. One impact wrench and a hex adapter and hex socket.

At the Falls City, Texas, gas compressor station of Southern Minerals Corporation, delivery pressures increased beyond the design pressure for the compressors. Engineers decided that a secondary ring of head bolts would prevent gas from leaking out between the head gaskets. Rather than remove the cylinder from the compressor frame, the modification was performed in the field, saving both time and money.

2 After the compressor is shut down, the water drained, and pressure released, the impact wrench is used to remove the ten head nuts.

3 Using the cylinder head studs, a drill jig is bolted to the cylinder. The drill is used to make four 21/32-in. diameter holes 1½-in. deep in the high grade cast-iron alloy. Drilling time per hole averages 45 seconds. Total drilling time is 5 minutes.

4 After the drill jig is removed, the reversible vertical piston drill is used to tap the four holes.

5 The impact wrench is used to drive four studs into the tapped holes.

6 After the cylinder heads and gaskets have been replaced, the impact wrench is used to drive the 14 head nuts onto the cylinder studs.

7 The modification completed, the compressor is operating again, 2 hours and 30 minutes after it was first shut down. Modification of another compressor required only 1 hour and 10 minutes.

How To Use

Bonded-Wire Strain Gages

For Determining Secondary Stresses in Pipe Lines

D. L. Shipp, G. M. McClure, and H. J. Grover
Battelle Memorial Institute, Columbus, Ohio

Part Two

EXCLUSIVE

Strain-Gage Circuits and Instrumentation

After the strain gages have been properly oriented, cemented, and at least partially dried, preparations can be made to connect the gages into a strain-measuring circuit. A typical circuit might contain a group of measuring gages, one or more compensating gages, a switching unit, and a suitable strain-indicating or recording unit. The selection and arrangement of the circuit components are vital factors in obtaining accurate and reliable strain data.

The Wheatstone-Bridge Circuit

The operation of the gage is based on the proportional relationship between strain on the grid wire and the resistance of the wire. The electrical property which must be measured, therefore, is the change in resistance, $\triangle$ R, resulting from a given strain on the gage grid. The objective of the strain-gage circuit is to measure accurately only those changes in resistance caused by strains in the test piece and to exclude or cancel out the resistance changes arising from other sources.

An idea of the magnitude of the resistance changes that must be measured can be gained by considering a typical installation of a 120-ohm gage on a steel test bar. Suppose the gage has a strain sensitivity (gage factor) of 2.00 and that it is oriented along the axis of the bar under simple compression or tension stress. The change in resistance, $\triangle$ R, in this case, would be only about 0.008 ohm for each 1000-psi increment of stress. For this reason, it is desirable to be able to measure $\triangle$ R to within about 0.001 ohm.

Editor's Note: **The Pipeline Engineer** is pleased to publish as a service to the pipe line industry this report on the use of bonded-wire strain gages for determining secondary stresses in pipe lines. This article, which is being published in two sections (the first section appeared in the November issue of **The Pipeline Engineer**) has been made available through the courtesy of the Pipeline Research Committee of the American Gas Association, for whom this research was performed as part of the AGA's PAR (Promotion-Advertising-Research) Plan.

A convenient method to determine resistance to a high degree of accuracy is by a Wheatstone bridge circuit. This type of circuit, shown schematically in Fig. 4, is generally used in making strain-gage measurements. When this circuit is balanced, that is, when the resistance R_1, R_2, R_3, and R_4 are adjusted so that no current flows across the bridge output, the following relationship is true:

$$\frac{R_1}{R_4} = \frac{R_2}{R_3}, \text{ or } R_1 = R_4 \frac{R_2}{R_3}$$

Strain Indicators

In the most commonly used strain-gage circuit, the resistance R_1 would be the "active" or strain-measuring gage and R_4 would be a "dummy" or temperature-compensating gage. R_2 and R_3 are part of the measuring instrument. The dummy gage is not stressed and it acts only to cancel out changes in resistance in the active gage caused by temperature changes.

From the equation, then, a change in the resistance of R_1 (caused by strains on the test member) can be measured by determining the corresponding change in the ratio $\frac{R_2}{R_3}$ required to bring the bridge circuit back into balance. This ratio is determined by the static strain indicator which can be considered a very sensitive ohmmeter calibrated in terms of strain. Fig. 5 is a simplified block diagram illustrating the principle of a typical strain indicator circuit.

In this system, the measurement of $\triangle$ R is accomplished by bringing the bridge resistances into balance. This null-balance technique is very accurate for determining static or slowly changing strains. It is used in manually operated strain indicators as well as automatic null-balancing instruments such as dial-type indicators or strain recorders.

Another method of determining change in resistance of the active gage would be to measure the difference in bridge output current. Referring to Fig. 4, if R_2, R_3, and R_4 are held constant after bringing the bridge into initial balance, then a small change in R_1 will cause a nearly proportional change in output current (provided the bridge input current is held constant).

Thus, it is possible to determine $\triangle$ R without rebalancing the bridge for each reading. This system, however, is generally less accurate than the null-balance technique. It is used extensively in dynamic strain-measuring equipment where the bridge-balancing procedure would be too slow to follow the strain pattern. The system is also used in some types of static-strain indicators which have direct-reading meters calibrated in unit strain. The strain indicator as diagrammed in

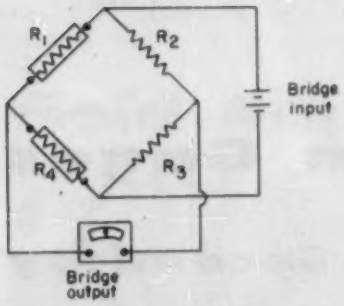


FIG. 4. Wheatstone bridge circuit.

Fig. 5 employs an a-c bridge power supply combined with an a-c amplifier. This type of circuit provides a stable and accurate means of measuring strains, and it has been used extensively in portable static-strain indicators. Recent advances in the development of d-c amplifiers, however, may lead to a more common use of d-c equipment for measuring static strains.

Listed below are some of the manufacturers of portable, static strain-measuring equipment. No attempt will be made to discuss the various dynamic instrumentation available, since the measurement of secondary stresses in most cases will not require this type of equipment. For an informative discussion of dynamic strain equipment and circuitry, see Reference 8.

Manufacturers of Portable, Static-Strain Indicators*

Baldwin-Lima-Hamilton Corporation, Electronics and Instrument Division, Waltham 54, Massachusetts.

Cole Instrument Company, 1320 South Grand Avenue, Los Angeles 15, California

Ellis Associates, Box 77, Pelham, New York

Hathaway Instrument Company, Denver, Colorado

Nosker Engineering Products, Yellow Springs, Ohio

N. V. Phillips Company, Eindhaven, Netherlands

Polyphase Instrument Company, Bryn Mawr, Pennsylvania

Young Testing Machine Company, Norberth, Pennsylvania

The Compensating Gage

Going back to the basic circuits shown in Fig. 4 and 5, it will be noticed that one arm of the bridge, R_4, was designated as the "dummy" or compensating gage. This gage should have very nearly the same electrical and thermal properties as the active gage. This is accomplished by selecting gages from the same package lot. It is essential that the compensating gage be bonded to an unstressed piece of the same type of material as that to which the active gage is bonded.

During the tests, the compensating gage and leads must be at the same temperature or temperature gradient as the active measuring gage and leads. Obviously, there may be considerable variation in temperature on large structures, especially if part of the structure is exposed to the sun or some other source of heat radiation. For this reason, the compensating gage, mounted on a small unstressed plate, is often placed in contact with the test structure directly adjacent to the active gage, and the leads from the active and compensating gages are run in a common cable to the indicator. In pipe line work, it is convenient to mount the dummy gage on a small piece (about 2½ by 5-in.)of the same diameter pipe as that to which the active gages are applied. In this way the dummy gage piece can be neatly fitted against the pipe wall.

Lead Wires and Connections

Lead wires are another component of the bridge circuit which deserve special attention. Generally, solid copper wire of 18 to 20 gage is preferred for strain-gage work. If the use of stranded wire is necessary, care should be taken to solder all of the strands together where connections are made. It is good practice to place a small expansion loop at the point where the leads are attached to the fine strain-gage leads in order to prevent strains on the lead wires (see Fig. 3c). The connections to the gages should be carefully tinned and soldered, using a rosin-core solder. A small soldering gun (pistol-grip type) as used in radio shops is handy for this application.

The type of wire insulation required will depend upon the location of the test. Generally, any of the plastic insulations are adequate. In extremely humid or underground locations, a rubberized or direct-burying type of cable should be used. Shielded leads may be required in some locations where undesirable electrical interference is present.

Where lead lengths are extremely long, or where the length of the active gage lead varies considerably from that of the compensating gage lead, several special problems arise. The first of these is a possible capacitance unbalance in the leads which can cause a marked decrease in the meter sensitivity. This situation can be corrected by placing a variable capacitance in parallel with one of the gages and adjusting until maximum meter sensitivity is achieved. (See manufacturer's instruction books for detailed procedures.)

Resistance of extremely long wire introduces a small error in the circuit. This can be compensated for by adjusting the gage factor setting according to the following approximation (assuming that the leads to the active and compensating gages are nearly equal in length):

$$\text{New gage factor setting} = F - \frac{R_w/R_g}{2}(F),$$

where

F = true gage factor (specified by manufacturer),
R_w = resistance of the lead wires to the active gage,
R_g = resistance of the strain gage.

For example, say, a 120-ohm active gage 100 ft from the strain indicator were hooked up with 18-gage copper wire (6.5 ohms per 1000 ft): The resistance of the leads to the active gage would be $2 \times 100 \times 0.0065 = 1.3$ ohms. If the specified gage factor were 2.00, the correct gage factor setting would be:

$$2 - \frac{1.3/120}{2} \times 2 = 1.99.$$

Setting the gage factor at 1.99 instead of 2.00 will automatically compensate for the error due to lead resistance. The above approximation should not be used if the lead-wire resistance becomes greater than 5 per cent of the gage resistance.

Multiple Gage Circuits

Frequently, it is desirable to hook up large numbers of strain gages in a single strain-measuring circuit. A wiring diagram of a typical setup is shown in Fig. 6.

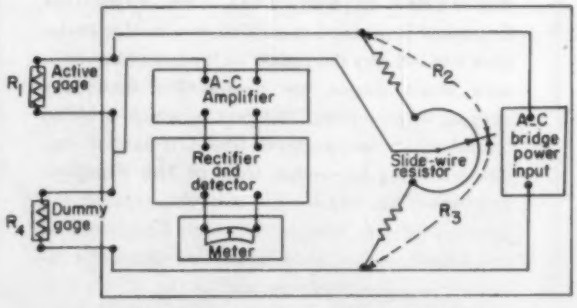


FIG. 5. Block diagram of a strain indicator with a-c amplifier and a null-balance meter.

*This list was compiled from trade literature on file at the Instrument Laboratory at Battelle Memorial Institute. It is not necessarily a complete list of all manufacturers of the subject equipment.

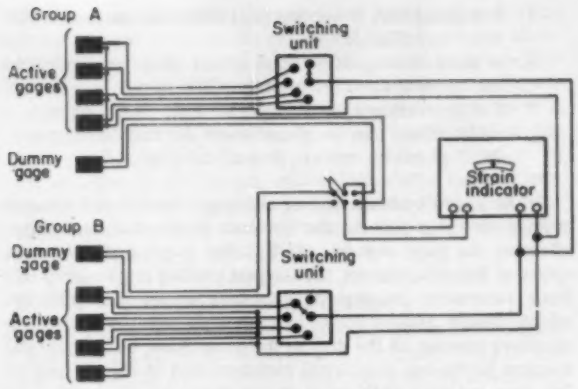


FIG. 6. Multiple strain gage circuit.

It is generally convenient to separate the gages into groups as shown schematically in Fig. 6, depending upon the location and type of gages, the number of compensating gages required, and the type of strain-measuring equipment used. It will be noticed that the active gages in Group A (Fig. 6) are hooked together with a common wire. The accidental grounding of any one gage in this type of circuit could ground the entire group. Where the gages will be inaccessible after the testing begins (as in underground installations), it might be desirable to run individual leads to each gage (as shown in Group B, Fig. 6), so that a defective gage can be cut out of the circuit without difficulty. In any location, grouping the gages will limit the effects of defective gages and will aid the location and correction of trouble in the circuit.

Strain-gage switching units are available commercially or they can be made up by using high-quality radio-type switches. Considering that an accuracy of measurement of 0.001 ohm is desired, the strain-gage switch should be of dependable construction giving a minimum and reproducible contact resistance. Frequently, 6-circuit, 11-position radio switches are used with all six circuits wired in parallel to lower the contact resistance. When only a few gages require switching, a good double-pole, double-throw knife switch will work satisfactorily, provided the contacts are kept free of dirt or grease.

Checking the Circuit

During the installation of the gages and circuits, there are several quick tests to check for faulty gages or electrical connections. A small multirange ohmmeter will serve well for this purpose. The instrument used should be capable of detecting low resistances of the order of 60 to 500 ohms, as well as high resistances to ground of the order of 1 to 500 megohms. A high-voltage insulation tester should not be used since the gage could be ruined by damaging its insulation. (A maximum of 22½-v is recommended as the applied voltage for resistance-to-ground measurement.)

The resistance of the strain-gage grid should be tested before the gage is hooked into the circuit. The cement need not be completely dry for this test. Any noticeable variation from the manufacturer's specified gage resistance would indicate a faulty gage.

Tests for resistance to ground should be made after the cement is thoroughly dried or cured and before the gage is wired into the detecting circuit. The operator should make certain that the ohmmeter probes make good contact with the grid lead and test structure or ground.* A resistance to ground of 10 megohms or less is unacceptable unless the gages are used only for short-run dynamic tests. A resistance of 50 megohms is considered adequate for short-term static measurements. A properly installed and thoroughly dried gage should show 500 to 1000 megohms to ground. The resistance checks should be repeated as the various components of the measuring circuit are installed.

Another test which may be performed after completing the circuit consists of applying slight pressure to the gage with the fingers or a lead-pencil eraser and noting the reaction on the strain indicator. Pressure on a sound gage should cause only a slight indication of strain. On releasing the pressure, the indicator should return to its original position. Instability of the gage because of damage or faulty bonding could cause the indicator to become erratic or permanently displaced.

Methods of Protecting Strain Gages From Moisture and Mechanical Damage**

One of the problems in the use of bonded-wire strain gages is to keep the gage grid and leads electrically isolated from all external conductors such as the test structure or the surrounding media. This problem is aggravated by the fact that some of the most conveniently applied cements tend to absorb moisture and become slightly conductive. Since it is frequently desirable to measure stresses under humid conditions or under conditions of actual hydrostatic pressure, some means must be provided to keep moisture from reaching the gage and leads.

A considerable number of coatings have been used by various investigators in a search for the ideal strain-gage coating. Because of the wide variety of gage applications, however, there is not universal agreement as to the best coating techniques. Some of the factors to be considered in selecting the proper coating are:

1. **Electrical resistance of the coating,**
2. **Resistance to passage of moisture,**
3. **Ability of the coating to bond to the test structure,**
4. **Degree of mechanical protection provided by coating,**
5. **Behavior of coating at extreme temperatures,**
6. **Effect of aging,**
7. **Effect of various chemicals present in the test area,**
8. **Cost,**
9. **Ease of application and time required.**

Actually, the final selection of a coating or combination of coatings will depend to a great extent upon the degree of protection required. This will range all the way from no coating for short-time indoor installations to maximum protection against moisture and mechanical damage for long-time underground installations.

Before any coating is applied, the gage must be thoroughly dried or cured. The leads should be properly connected to the gage and secured to the test structure (see Fig. 3c). It is good practice to clean and roughen the lead wire insulation and to make sure that the coating flows all the way around the lead wires to insure a moisture-tight seal. The surface in the area surrounding the gage should be thoroughly clean and free from the gage cement (see Fig. 3d). In many cases, moisture will be found to seep into the gage through the seal between the coating and the surface or lead wire rather than through the coating itself.

A very suitable coating for most indoor applications is a microcrystalline wax called Petrosene. This material offers good moisture protection and some protection against mechanical damage. It can be used where the temperatures fall

*In some underground locations, care should be taken to prevent erroneous readings or other difficulties which might stem from voltages applied to the line for cathodic protection.

**Since this report was written, a report of an extensive investigation of methods of waterproofing gages has come to the attention of the authors: Dean, Mills III, "Techniques for Protecting and Waterproofing Resistance Wire Strain Gages," David W. Taylor Model Basin Report 797, March, 1956.

within the range of about 40 to 160F. Petrosene is applied by brushing the melted material over the heated gage and surrounding surface. It is essential that the surface be heated (preferably to 160 to 180F) in order to make a good bond with the wax. As the surface cools, the wax coating can be built up to the desired thickness, usually about 1/16 to ¼-in. Petrosene is used generally under moderate conditions of temperature and humidity, and it has excellent stability for long-time applications.

In underground locations or under other extreme conditions, the use of two or more coatings may be required to get adequate protection. Experiments on various combinations of coatings under extreme conditions have been in progress at Battelle Institute during the past nine months. In these tests, strain gages were mounted on 180-deg segments of 24-in. pipe about 5-in. wide.

In order to simulate actual field conditions, a threaded rod was installed across the open end of each segment and tightened down until the metal under the gages was strained to about 800 microinches per inch. The segments were then immersed in a drum of water containing some salt in solution. Readings of strain and resistance between the test gages and the water bath have been made periodically over the nine month period.

Table 2 shows the different combinations of coatings tried in this experiment and the results obtained to date. In view of this experiment and of experience from actual field tests on buried pipe lines, the following procedure is recommended for weatherproofing under extreme conditions:

1. Coat the gages and lead ends with Glyptal enamel and heat dry at 120 to 180F for 1 hour. The Glyptal coating should cover both the strain gage and its bonding cement (see Fig. 3d).
2. Four successive coats of Neoprene (liquid synthetic rubber) are applied over the Glyptal. Each coat is dried about one-half hour at 120F. The neoprene coating should extend over a larger area than the Glyptal to form a seal with the pipe surface.
3. Petrosene wax is applied next while the surface is still hot. (See Fig. 3f).
4. A final coating of silicone grease may be applied to the entire area of the gage installation.
5. For protection against rocks or other sharp objects, a metal shield can be placed over the individual gages, or, if possible, entirely around the pipe.

In the above combination of coatings, the Glyptal enamel mainly serves to prevent the solvents in the neoprene from affecting the gage cement. (If Bakelite gages are used with epoxy or Bakelite cement, the Glyptal coating can be omitted.) Four successive coatings of neoprene insure that pinholes which almost always occur in each coat will not provide a moisture passage all the way to the gage. Also, each neoprene coating forms one additional moisture seal at the surface of the pipe and around the lead wire to the gage. The wax gives additional mechanical protection to the gage and undercoatings, and it provides good moisture protection under moderate conditions. The final coating of silicone grease is optional; however, because of its ease of application the grease is often used as an additional moisture barrier. Table 2 contains a list of sources for the weatherproofing materials.

Field experience and laboratory tests have shown that in applying any thin waterproofing material (such as neoprene or Glyptal) one of the most important things is to apply several coats to prevent pinhole moisture leaks to the gage. Another important factor is to have both the surface surrounding the gage and the lead-wire end thoroughly clean in order to form a moisture-tight seal with the coating. Finally, the coatings must have adequate protection from possible mechanical damage in order to remain water-tight during the testing period.

Special Precautions for Long-Time Strain-Gage Application

One of the most exacting applications of strain gages is that where all of the readings must be related back to an

TABLE 2. Results of Experiments on Various Waterproofing Materials.

Strain Gage Type	Cement	Weatherproofing Materials (*)	Resistance to Ground	Deviation in Strain Reading
A-3	Duco	3 coats Insl-X E-33 primer 1 coat hot-coal tar enamel, plasticised 1 coat silicone grease covered with polyethylene sheet	1.8 megohms (After 3 months)	+300 microinches/inch
A-3	Duco	4 coats Insl-E X-33 primer 1 coat hot-coal tar enamel, plasticised	<1 megohm (At start of test)	—
A-3	Duco	1 coat Fybrglas (auto-body repair materials) 1 coat silicone grease covered with polyethylene sheet	100+ megohms (After 9 months)	Negligible
A-3	Duco	1 coat Fybrglas (auto-body repair materials)	100+ megohms (After 8 months)	Negligible
AB-3	Epon 828	4 coats Glyptal enamel 1 coat Petrosene wax 1 coat silicone grease covered with polyethylene sheet	100+ megohms (After 9 months)	Negligible
AB-3	Epon 828	4 coats Glyptal enamel 1 coat Petrosene wax	100+ megohms (After 8 months)	Negligible
AB-3	Epon 828	4 coats liquid neoprene 1 coat Petrosene wax 1 coat silicone grease covered with polyethylene	100+ megohms (After 9 months)	Negligible
AB-3	Epon 828	4 coats liquid neoprene 1 coat Petrosene wax	100+ megohms (After 8 months)	Negligible

*Sources for coating materials.

Coating Material	Manufacturer or Supplier
Fybrglas	Schramm Fiberglass Products, Inc., Chicago, Illinois
Glyptal No. 1201, red enamel	General Electric Company
Insl-X E-33 primer	The Insl-X Company, Inc., Ossining, New York
Gaco N-700 liquid neoprene	Gates Engineering Company, Wilmington, Delaware
Petrosene microcrystalline wax	Socony-Mobil Oil Company
Silicone grease, type DC-4	Dow-Corning Company, Midland, Michigan
Coating supplies, general	Baldwin-Lima-Hamilton Corporation, Waltham 54, Massachusetts

initial zero reading which may have been taken several months or even years in the past. In this type of test, where there is no possibility of reproducing the "zero" condition, the reliability of the results obtained is dependent upon the accuracy and stability of the total strain-gage circuit over a long period of time. Fortunately, some components of the system can be checked for stability during the test period. In other portions of the circuit, special techniques must be employed to minimize the effects of time, moisture, and temperature, and to prevent mechanical damage during the course of the test.

Strain-Gage Creep

One source of error that probably is present to some degree in any strain-gage measurement is gage creep. This is the name given to the slight slipping or yielding of the strain-gage bonding material over a period of time. Gage creep is characterized by a gradual falling off of indicated strain when the test piece is maintained under a constant load. Although the error from this source is normally very small, especially when the readings are taken over a short period of time, gage creep may introduce a sizable error in long-time applications where the gage cement may be affected by absorption of moisture, aging, or high temperature.

Methods of minimizing gage creep are as follows:

1. Make certain that the gages have been thoroughly dried or cured. (Final curing temperature should exceed the maximum operating temperature.)
2. Apply weatherproof coatings to the gages while in their dry condition. Under conditions of high humidity, this would require heating of the gage prior to coating.
3. Select the longest gage length possible, as the larger gages generally exhibit more stability.
4. Use Bakelite strain gages and cement if conditions permit, since these gages show the least change when subjected to aging, high temperatures, or moisture.
5. When conditions permit, it is desirable to cycle the gages to maximum temperature and load several times just prior to testing.

Instability of the Strain Indicator

Another source of possible error lies within the strain indicator or recorder. Any of the electrical components in the strain indicator circuit could cause a zero drift over a period of time. One of the most frequent causes of drift within the indicator, however, is a change in the applied bridge voltage. This may be caused by normal battery decay or by changes in line voltage if the instrument is operated from a conventional a-c power source.

There are several methods of preventing indicator drift from introducing errors in the strain readings. One would be to maintain a closely regulated power supply to a strain indicator whose characteristics under various conditions of temperature, humidity, and time are known. Another more practical method is to detect the amount of drift present at the time strain readings are made and to correct the readings accordingly. (This does not imply that a stable, well-compensated instrument is not required. The drift is greatly minimized in commercially available strain indicators.)

One of the easiest ways to detect the amount of indicator drift is to set up two zero-reference gages. These would be preferably two Bakelite gages from the same lot cemented to a small unstrained steel plate and weatherproofed. The plate might be attached to the wall in an office or laboratory where it will not be disturbed. The gages are connected to the indicator in the usual active, compensating arrangement. A zero reading should be taken on the reference gages just before the test gages are zeroed and at each time that the strain readings are taken during the test. Any indication of strain in reference gages can be regarded as a zero shift in the indicator.

For example, if the initial reference reading were 10,000 microinch per inch. (assuming a null-balance type indicator) and this reading decreased to 9950 microinch per inch at some time during the test, this would indicate a zero shift of —50 microinch per inch. In order to correct the strain readings, the amount of the zero shift should be subtracted, algebraically, from each of the strain readings (taking tension readings as + and compressing readings as —).

It should be emphasized that the zero-reference gages serve only as a check on strain indicator. They cannot be used to detect gage creep or zero drift in the other portions of the strain-measuring circuit.

Other Sources of Circuit Instability

Several other sources of error in strain measurements are:

(1) Low resistance to ground;
(2) Improper temperature compensation of the gages;
(3) Changes in impedance between the gage leads, and
(4) Mechanical damage of gages or leads.

In long-time tests, particularly under adverse conditions, the resistance to ground of the gages and leads should be measured and recorded on each occasion that strain readings are made. It is desirable to maintain at least 100 megohms resistance to ground when the readings are to be related back to an initial reading over long periods of time. Leakage resistances of less than 50 megohms will give results of uncertain accuracy. It has been found in field measurements in the past, that moisture, causing low resistance to ground, is the chief cause of unreliable strain readings. For this reason, the importance of good moisture-proofing of the gages and lead wires cannot be overemphasized. The leakage resistance may be impaired also by the use of improper soldering fluxes such as acid.

To obtain temperature compensation, it is necessary to have both the "dummy" and active legs of the measuring bridge under identical conditions of temperature. This includes the strain gages as well as the leads to the gages. In outdoor tests and, in many cases, in indoor tests, sunlight may cause large changes in temperature and temperature gradients in the test structure. Also temperature gradients may be induced by normal operating conditions. It is important that the compensating gage and leads be subjected to the same temperature fluctuations or gradients as the active gage and lead. Generally, this is accomplished by locating the compensating gage as close as possible to the active gage and running the leads from both gages in a common cable.

A fluctuating impedance between the gage leads can affect the accuracy of the strain readings. In an a-c powered circuit the impedance is affected by the relative position of the gage leads with respect to each other. For this reason, the leads should be fixed in position during the test. A convenient method of handling large numbers of leads is to tape or bind them together to form a single cable. Moisture absorbed by insulation will also affect the impedance between the leads. Under humid conditions, a rubberized or direct-burying type of cable should be employed to prevent moisture absorption.

Mechanical damage is detrimental when it is severe enough to cause a small change in resistance in the gage or leads without causing a direct short or break in the circuit which can easily be detected. Overflexing or pinching of the lead wire can cause a change in resistance in the wire. Also, improperly soldered joints are especially susceptible to slight strains or vibrations in the lead wires and can cause considerable variation in resistance. When the gages are to be inaccessible during the test, it is sometimes desirable to place alternate gages at critical locations and to provide several alternate compensating gages. In this way, the operator has some means of cross checking for possible mechanical damage in the circuit should any unusual readings occur.

Analysis of Results

Once the application of the strain gages and other measuring instruments has been completed and a series of readings of the gages taken, it will be found that only a small portion of the total job has been completed. A large part of the overall investigation is in the analysis of the results and the presentation of the data in some useful form.

In most cases, it is desirable to calculate stresses from the gage readings and work with them rather than the actual strain values. Normally these calculated stresses are then compared to predicted design stresses and also considered in the light of the pressure, temperature, or other loads that have produced them.

Examples of the method by which stresses can be calculated from three different strain-gage arrangements are as follows.

Calculation of Stresses

In the case of a single gage, the strain values indicated by the gage are merely multiplied by Young's modulus of elasticity to obtain the stress. This does not take into account the Poisson effect; for more accurate determination of stress, a pair of gages or a rosette gage must be used.

All SR-4 strain gages are slightly sensitive to strains in the direction perpendicular to the axis of the gage, because a small fraction of the strain-sensitive grid wire is effectively in the perpendicular direction. Consequently, when a gage is used in a biaxial-stress field the indicated strains are slightly in error (since the gage factor supplied by the manufacturer is calibrated in a uniaxial field). The maximum error in an A-type gage used on mild steel might be 3 per cent. In the following discussion this "transverse sensitivity" is neglected.*

When a pair of perpendicular gages is employed, the strains indicated by the gages may be substituted into the following formulas to obtain the stresses.

$$\sigma_1 = \frac{E}{1 - \nu^2}(\varepsilon_1 + \nu\varepsilon_2), \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\sigma_2 = \frac{E}{1 - \nu^2}(\varepsilon_2 + \nu\varepsilon_1), \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where

σ_1, σ_2 = the stresses in the direction of each gage, respectively,
$\varepsilon_1, \varepsilon_2$ = the strains obtained from each gage, respectively,
E = Young's modulus of elasticity,
ν = Poisson's ratio.

In most gage installations where only a pair of gages is used, it is advisable to orient the gages so that the Subscripts 1 and 2 above will represent the longitudinal and circumferential directions in the pipe.

In cases where a 45-degree rosette strain gage is used, the principal strains and principal stresses and their direction can be calculated as follows:

$$\varepsilon_p = \frac{1}{2}\left[\varepsilon_1 + \varepsilon_3 + \sqrt{(\varepsilon_3 - \varepsilon_1)^2 + (\varepsilon_3 + \varepsilon_1 - 2\varepsilon_2)^2}\right] \quad . \quad . \quad . \quad . \quad (3)$$

$$\varepsilon_q = \frac{1}{2}\left[\varepsilon_1 + \varepsilon_3 - \sqrt{(\varepsilon_3 - \varepsilon_1)^2 + (\varepsilon_3 + \varepsilon_1 - 2\varepsilon_2)^2}\right] \quad . \quad . \quad . \quad . \quad (4)$$

$$\tan 2\theta = \frac{(2\varepsilon_2 - \varepsilon_1 - \varepsilon_3)}{(\varepsilon_1 - \varepsilon_3)},$$

where the Subscripts 1, 2, and 3 denote the direction of each of the three elements in the rosette gage, respectively, and

ε_p = maximum principal strain,
ε_q = minimum principal strain,
θ = the angle in degrees measured in a clockwise direction from Element 1 of the gage. (Provided the gage elements are numbered in a clockwise direction.)

The direction of the minimum principal strain is always 90 deg from the direction of the maximum principal strain. The directions of the maximum and minimum principal stresses are defined in like manner. The magnitudes of the principal stresses are defined by

$$\sigma_p = M\varepsilon_p + N\varepsilon_q$$
$$\sigma_q = M\varepsilon_q + N\varepsilon_p,$$

where

σ_p, σ_q = maximum and minimum principal stresses, respectively

$$M = \frac{E}{1 - \nu^2}\left(1 - \frac{\nu}{b}\right)$$

$$N = \frac{E}{1 - \nu^2}\left(\nu - \frac{1}{b}\right)$$

$\frac{1}{b}$ = auxiliary factor for the strain gage to correct for the cross-strain effect on the gage. This is supplied with each package of gages purchased.

Analysis of Pressure and Temperature Effects

The combination of internal pressure and temperature on a pipe introduces a different force stress or strain effect than one usually encounters in practice. It might be well to discuss these effects here since they are often met in an experimental stress analysis in a pipe line. In what follows, let us consider only the longitudinal forces and stresses produced in a pipe by pressure and temperature.

First, assume that a pipe with end caps is subjected to internal pressure. The pipe elongates and a longitudinal stress is developed in the pipe wall equal to one-half of the circumferential stress. The longitudinal strain with these conditions is about one-fourth of the circumferential strain.*

Now assume that the same pipe with end caps is subjected to internal pressure, but is restrained from elongating by a continuous soil friction along the pipe such as is encountered in a long buried pipe line. The longitudinal strain in the pipe wall and the elongation of the pipe will be reduced to zero. The longitudinal stress, however, will be a tensile value equal to Poisson's ratio times the circumferential stress.

Now let us consider the effect of temperature changes on the pipe. If the pipe is heated and allowed to elongate, the longitudinal stress in the wall will be zero, while the longitudinal strain will equal the product of the coefficient of thermal expansion and the temperature change.

If, however, the pipe is restrained from elongating, a longitudinal compressive stress will develop equal to the product of the coefficient of thermal expansion, the temperature change, and the modulus of elasticity, while the longitudinal strain will be zero.

To summarize, with no longitudinal restraint, internal pressure in the pipe produces a longitudinal strain and a tensile longitudinal stress, whereas a temperature change produces a longitudinal strain and no longitudinal stress. With complete restraint, internal pressure produces no longitudinal strain but a tensile longitudinal stress, while a temperature change produces a compressive longitudinal stress but no longitudinal strain.

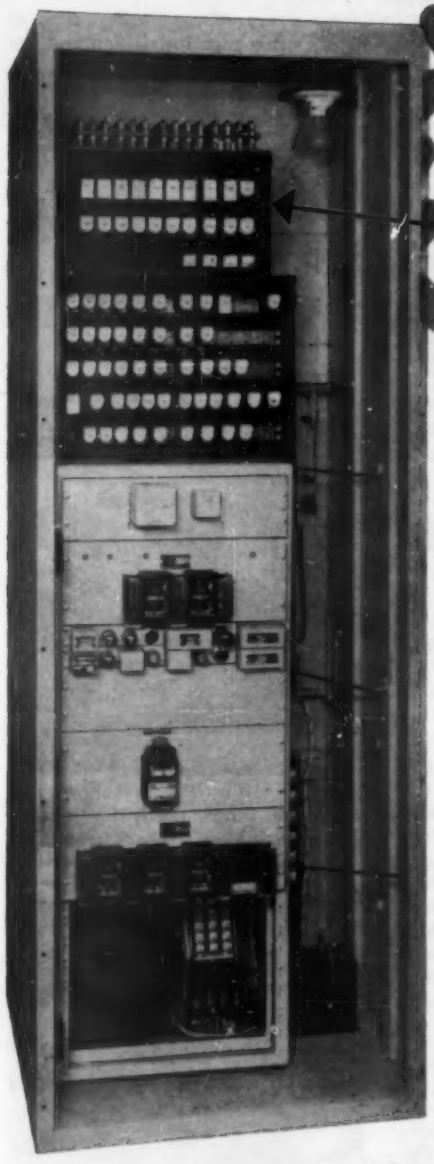
Now let us consider the readings that are obtained from a strain-gage circuit on the pipe. These readings indicate tem-

*Further discussion of the transverse sensitivity of SR-4 gages can be found in Reference 8, p 141.

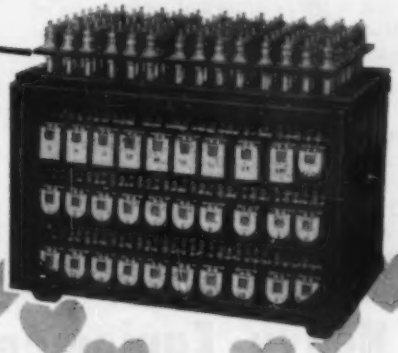
*This can be shown by substitution of the proper values for circumferential and longitudinal stress and for Poisson's ratio in Formulas 1 and 2.

Millions of "heartbeats" prove the reliability of

UNION C.T.C. Centralized Transport Control



"HEART" OF THE SYSTEM . . . is the coding unit consisting of a group of relays which transmit all control codes to the field and receive all indication and digital information from the field.



A control system is only as good as its vital parts. That's why it's so important that every component meet the quality standards of the main system. For this reason, Union Switch & Signal designs and manufactures all the important parts that go into its centralized transport control systems.

The "heart" of the UNION System is the coding unit. This consists of a group of relays that transmit all the control codes to the field and receive all indications and digital information from the field. The design of these relays features extreme ruggedness and reliability. Service records in other applications show the relays are capable of millions of operations.

This is an example of the reliability that is built into the components used in the UNION C.T.C. System. It means that you can expect a UNION System to go to work and *keep on working* with the least possible maintenance cost. Write for a copy of our Bulletin SPL 1052 for complete information.

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perature strains which are somewhat reversed from the considerations above, yet the stresses calculated from the strains are correct.

As suggested in the previous section of the report, assume that a strain-gage circuit is employed in which the dummy gage is applied to a piece of pipe material in such a manner that it is at the same temperature as the active gages on the pipe. With this arrangement, if the temperature of the pipe is increased and no restraint is offered against longitudinal expansion, both gages will elongate the same amount and the strain indicator will indicate zero strain. Substitution of zero strain values in Formulas 1 and 2 gives zero actual stress.

If, however, the pipe is completely restrained and its temperature is increased, the active gage will not elongate but the dummy gage will elongate just as before. A negative strain will then be indicated by the instrument which will result in a calculated compressive stress from the above formulas.

Thus, under the condition of a heated pipe which is not restrained, partially restrained, or fully restrained, the strain-gage circuit will yield strain values just opposite from the actual strain in the pipe; but when these values are substituted in the stress formula, the correct stress values are obtained.

To investigate this matter in more detail, assume that a pipe is subjected to an increase in temperature and some degree of restraint against longitudinal expansion. The total restraining force can be expressed by the following equation.

$$F = AE\varepsilon_L - AE\alpha\Delta T, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$= AE\,(\varepsilon_L - \alpha\Delta T), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where

F = longitudinal restraining force, pounds
A = cross section of metal area, square inches,
E = Young's modulus of elasticity, psi,
α = temperature coefficient of expansion for steel; approximately 7×10^{-6} in. per inch,
ΔT = temperature change,
ε_L = longitudinal strain in the pipe wall defined as $\Delta L/L$ — change in length divided by the original length.

It will be noted that in the top equation (5), the two terms on the right-hand side represent, respectively, the actual force in the pipe and the theoretical force in the pipe wall in the unrestrained condition. In the lower equation (6), the term $(\varepsilon_L - \alpha\Delta T)$ represents the strain given by the strain indicator when the dummy gage is at the same temperature as the active gages. This will always be a negative value for any amount of restraint and represents the difference between the $\Delta L/L$ strain in the metal and the theoretical strain $\alpha\Delta T$ for the unrestrained condition.

These pressure and temperature effects are important in analyzing the results of any strain-gage installation and are presented above because their improper interpretation sometimes leads to confusing conclusions.

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★ ★ ★

Loading Heavy Equipment Made Easy and Safe

Ramp designed in company shop is permanent part of "low boy"

Leon Lewis *Colorado Interstate Gas Company*

UNTIL recently, when the pipe line department of Colorado Interstate Gas Company at Denver, Colorado, wished to move heavy equipment such as draglines or Caterpillar tractors, the operation entailed some hard and hazardous labor. In order to load this equipment on the "low-boy" trailer, four or five men were needed to lift and push the heavy ramps into place in order for the equipment to be run upon the bed of the "low-boy." After loading the tractor or dragline, the ramps had to be lifted on the trailer so that they could be used in the unloading. Whenever the winch truck was available, the winch was used to hoist the ramps into place; however, the winch was not always available.

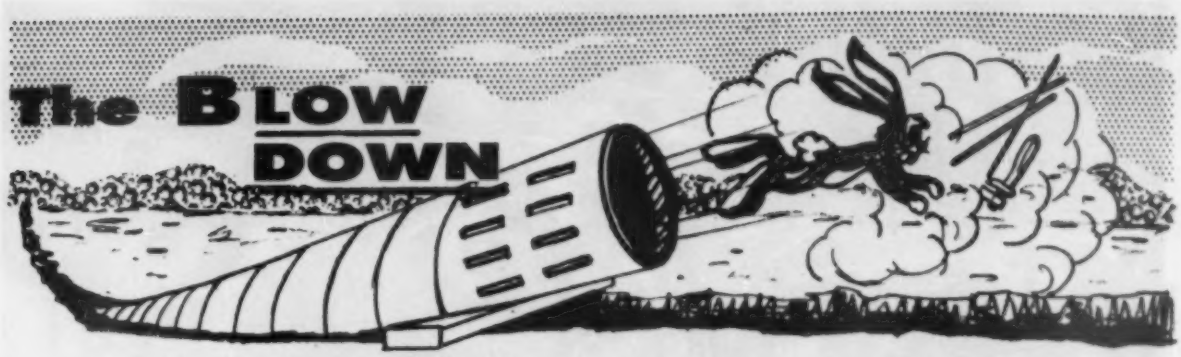
Not only was this method of loading and unloading heavy equipment slow and inconvenient, it was also hazardous from the safety point of view. Because of the weight and the unwieldly size of the ramps, there was always the possibility of injury to one or more of the men handling the ramps. Because of these undesirable factors, the boys in the pipe line department, and especially those whose duty it usually was to move the heavy equipment, got their heads together and with the help of Lawrence Jensen, the Denver pipe line welder, they designed a ramp that would be easy and fast to handle, and safe both in handling and in operation.

In constructing the ramps, Jensen used 6-in. I beams, 5 ft in length. For the tie straps he used steel straps, 1½ in. by ⅝ in. He fastened the ramps to the rear end of the trailer with a 1½-in. pin hinge. The ramps weigh about 90 lb each, and one man can easily lower them for loading and raise them for traveling.

We are indebted to *The Gasser*, Colorado Interstate's company magazine, for permission to excerpt this material from one of its articles.

Here the "low boy" truck is shown with the ramps down, ready for loading heavy equipment. From left to right: Lawrence Jensen, John Lakner and and Merle Porter.

With the job done, the ramps can be moved up (as shown here) and the "low boy" is ready to head for the next task.



News from the Field and Plant about People you know

Bob Ledford, vice president of Marine Gathering, has been elected president of the Pipeliner's Club of Houston. He succeeds THE PIPELINE ENGINEER'S Gulf Coast Editor, Don Taylor. The new vice president of the club is Raymond Crowe, chief engineer of Transcontinental Gas Pipe Line. The secretary is Bob Schuman, Truckline Gas senior engineer, and the treasurer is Wilbur Moore of Humble Pipe Line.

Some people wonder just how a Gulf Coast Editor of THE PIPELINE ENGINEER earns his board and keep. Mind you, this is not a pressing thing. As a matter of fact most of the wonderment comes from THE PIPELINE ENGINEER's headquarters office in Dallas and from my tailor, creditors, and children. (The latter always shy away from the subject when their cronies say, "My daddy works at the . . . etc.).

Actually, the work is *not* dishonest.

I attend the usual number of free cocktail parties (about three a week) and spend the rest of the time persuading pipeliners to write articles. (This is difficult. Most pipeliners had rather do things than write about them; besides, the average pipeliner limits his writing to about two postcards home to mother each year.) But most of my time is spent in traveling the Texas size Gulf Coast. By Texas size, I mean that it extends all the way from 77 miles out in the Gulf of Mexico to Seattle, Washington, Chicago, Milwaukee, South Bend, Indiana, and throughout the states of Utah, Wyoming, Colorado, Arizona, and New Mexico.

This travel is typical of pipelining in general, because mainly all pipeliners travel. When you see one of them in New York, he's on his way to Texas, and the one in Kansas City is on his way to Washington, etc. For the convenience of young pipeliners, THE PIPELINE ENGINEER has compiled the following *air travel aids*:

1. **The baggage crusher at the airport is not designed for cameras.** Its purpose is to slightly deform ordinary luggage so it will fit in the round shape of the airplane. When the ticket agent says, "I'll have to weigh the camera with the rest of your luggage." Never say, "If you're going to weigh it, you're going to ship it too." This is very bad. The camera gets caught in the teeth of the crusher or something, and it can seldom be repaired.

2. **In airline lingo, 10 minutes is longer than 30 minutes.** When the captain announces a 10-minute delay, he means 3 or 4 hours. When he announces a 30 minute delay, there's seldom time to go to the rest room.

3. **Never fall for the old saw about the station agent wanting to see you.** When you're seated with the plane full and one passenger standing in the aisle, tighten your seat belt when the stewardess says, "Mr.——— the station agent wants to see you just a minute." She implies there's an emergency long distance phone call. What she really means is that the plane is oversold and you are "IT." This gag is worth falling for once just to see how fast a plane can take off after you leave it.

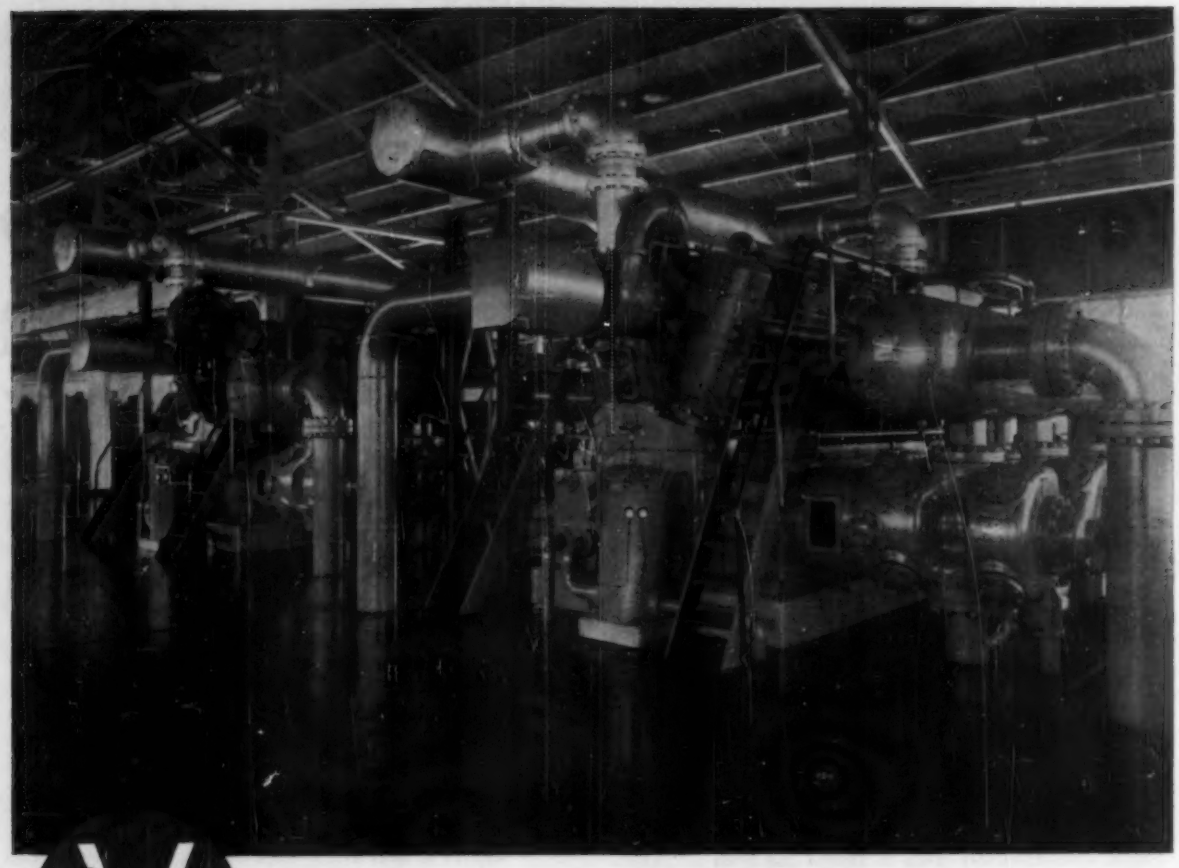
4. **Never — never tell your favorite airline story to the passenger sitting next to you.** Regardless of the indignities you suffered that time from the hands of XYZ Airline, the passenger can go you one better; then you have to tell another; and so on, until by the time you reach your destination, your neck is sore from turning your head toward him.

5. **Never sit next to a woman holding a small child.** You will end up holding it and chances are 999 to 1 you'll get drenched.

6. **Never sit directly over the wing,** because if you do you'll be sitting next to an elderly lady whose son works for the airline, and she rides it on a pass, day-in-and-day-out to have somebody to talk to.

7. **One of the world's most expensive meals is the difference between coach flight and first class flight.** The meal's not very good, though, and the airplanes are all the same.

Palmer L. Ledbetter, engineer (left) and **Joe Black,** chief engineer, at Southern Pacific Pipeline's El Paso station. Regretfully, Jack R. Davis, district superintendent, was in Tucson the day this photograph was taken.



KVS compressors are chosen for Palmyra Station of Northern Natural Gas Co.

When the Northern Natural Gas Company recently expanded its transmission station at Palmyra, Nebraska, two 2000-hp Ingersoll-Rand turbocharged KVS gas-engine compressors were put on the line to handle the capacity increase. An additional 2000-hp KVS unit is scheduled for installation at Palmyra this year.

These new 4-cycle units offer substantial fuel savings over older-type engines, floor space requirements are much smaller, and the operators appreciate the quiet operation.

Other significant features that go with the KVS include the flexibility and smooth operation characteristic of a 4-cycle unit, and the efficiency and dependability of I-R compressor cylinders with Channel Valves*.

Northern Natural was familiar with Ingersoll-Rand equipment, because there are over 75,000 hp of I-R gas-engine units at other stations of Northern and its subsidiaries. Other I-R products at Palmyra include the 4-cycle gas-engine generating units, the starting-air compressors and the cooling-water pumps.

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EXCLUSIVE

A 17-Year Cathodic Protection Program Has Paid Off

Large-scale application has proved economical and practicable for United Gas Pipe Line Company

United Gas Pipe Line Company was one of the first to give serious consideration to protection of its system against corrosion. The company began cathodic protection on work in the mid-thirties. This article, however, details its experience over the last 17 years, ending January 1, 1956. — Editor's Note.

G. R. Olson
United Gas Pipe Line Company

COST and results from application of cathodic protection for control of external corrosion on United Gas Pipe Line Company's system during a 17-year period are discussed in this article. The system includes 27,801 miles of coated and 14,759 miles of bare 3-in. equivalent pipe. At present, 37.2 per cent of bare and 85.1 per cent of coated pipe are being protected. In addition, United is protecting 1314 miles of 3-in. equivalent pipe owned by others. Table 1 summarizes conditions as of January 1, 1956.

Coordination contracts covering such installations are almost identical to that recommended by The Correlating Committee on Cathodic Protection in its report, which was published by the National Association of Corrosion Engineers in July, 1951. The first contracts became effective in 1940 and the others were executed in subsequent years.

Most of the bare pipe was in service in 1939 with an age of 12 to 20 years. During this 17-year period, less than 1.9 per cent of the present bare pipe system was replaced due to corrosion, usually in lengths of 20 to 200 ft at very special hot spots. During this period, corrosion leak rate on total system has been reduced by about 60 per cent. It is believed that the value of gas saved alone justifies control expenses exclusive of prolonged useful life of the system, reduced right-of-way damages, and increased safety.

This bare pipe system is operating today at greatly increased pressure as compared to 1939, and should serve a useful function for many years to come. Much of the 9563 miles of 3-in. equivalent bare pipe that is still unprotected, however, has now been in the ground 25 years or more and is seriously corroded.

History

During 1939 and the early forties, the United Engineers made extensive field and office studies with the following objectives:

1. Determine the benefits being derived from the 230 isolated rectifier, gas engine, and windmill units already installed on the pipe line system.
2. Determine whether practical to extend this type of corrosion control on a large scale, particularly on large diameter bare pipe.
3. Develop and/or adapt the most practical economic designs for field application.

In addition to studies on United's system, an exchange of information was established with other companies who were working on this same type of corrosion control. These contacts developed free interchange of practical experience with many engineers. They have since been maintained and enlarged whenever possible.

The early studies indicated quite clearly that large scale application of cathodic protection to bare, as well as coated lines, was both economical and practical. It is interesting to note that in the early forties most people in the gas business were of the opinion that there was a good chance of lines becoming obsolete, for one reason or another, within 15 to 20 years. It was difficult to get anyone to express a definite opinion that the useful life would be more than 15 years.

In those days, average cost of new lines was about $1000 per mile per inch of diameter, whereas today's costs are 3 to 5.5 times that amount. During the same period, costs of cathodic protection have increased less than 150 per cent. Today, every effort is made to design for indefinite life of underground lines. Those early economic studies were, of course, based on low cost of new pipe and relatively short useful life due to probable early ob-

solescence. Present day comparative cost data therefore are much more favorable to cathodic protection.

United's management was quick to see the advantage of expanding the use of cathodic protection and during the 17-year period covered by this report (1939 through 1955), made ample funds available each year to carry out an effective program.

Late in 1940, United began an ambitious program of extending the use of cathodic protection on its system. The first step was to develop the most effective and practical design methods. The main objectives were:

1. Reduce preliminary field testing to a minimum. (In those days it was necessary to do a great deal of field testing with portable generators and temporary ground beds to obtain data for each final design.)
2. Provide for the most efficient distribution of the relatively large volume of electrical energy required on large diameter bare pipe.
3. Provide construction designs and specifications that would permit maximum shifting of capacities and unit ratings to obtain final optimum efficiencies, after construction and testing was completed, with a minimum effect on overall final cost.

At that time, cost and results that had been realized on all methods used to that date were carefully studied, including large isolated units of various types, distributed anodes, and galvanic anodes. The designs finally decided on are what we call the "Distributed Capacity" type. Details, as well as preliminary results with this type design, were described in a paper.* Many detail improvements have been made in the last 17 years but the same basic principles are still being used. The results have exceeded original expectations and we believe these methods to be the most practical and efficient used to date.

Large-Scale Program in 1941

A few new installations were made in 1939 and 1940, but United's so-called large-scale program really got under way in 1941. At that time, the company had more than 20,000 miles of 3-in. equivalent pipe in service. Almost all of this pipe had been in the ground more than 12 years and many lines for more than 20 years. Most of them were originally laid with some type of coating such as hot and cold asphalts, coal tars, and greases of various types with or without outer wraps. Nearly all of the coatings had completely disintegrated prior to 1940, however, leaving bare steel exposed to the soil. An outstanding exception to this was the Baton Rouge-New Orleans lines. Low melting point coal tar enamel, without wrapper, was used on these lines, which were laid in 1927-29. Those coatings are still effective today in providing low cost corrosion control.

As of 1939 and 1940, corrosion leak repairs on this system were rapidly approaching a rate of 6000 per year. In the early forties, it was obviously impossible to install cathodic protection on this large system in one year or even 10 years. There weren't enough trained corrosion engineers in the country to design, surpervise, test, and adjust cathodic protection at that rate. For this reason the worst of the more corrosive sections of pipe were selected each year consistent with ability and capacity to execute. As stated, management has always provided ample funds for this program; however, many other bottlenecks were encountered, including shortage of materials, particularly during the war years, lack of trained corrosion engineers, and difficulties and delays in obtaining necessary right-of-way. Since the war, with the extremely rapid increase in corrosion control work throughout the country, shortage of suitable engineers for training has become increasingly acute.

Organizational Setup

As the number of installations on the system increased, the operating department's problems in providing trained maintenance personnel were multiplied manyfold. In order to be in line with district organization setup, where the same men are used jointly for communication, cathodic protection maintenance is divided into two phases, although they overlap to some extent. The first is what is called "Aboveground Operation and Maintenance." This consists of taking outputs and inspecting each unit at least once a month to see that they are kept in operation continuously at required output. During recent years, very effective results have been realized in this phase of the work.

The second phase is termed "Underground Maintenance" and consists of instrument checks at least once per year at each installation to see that the unit outputs are actually being used effectively. This work requires more technical training and consists essentially of measuring potentials on pipe, checking insulating points, checking dresser coupling bonds, and other special tests if and where leaks are still occurring.

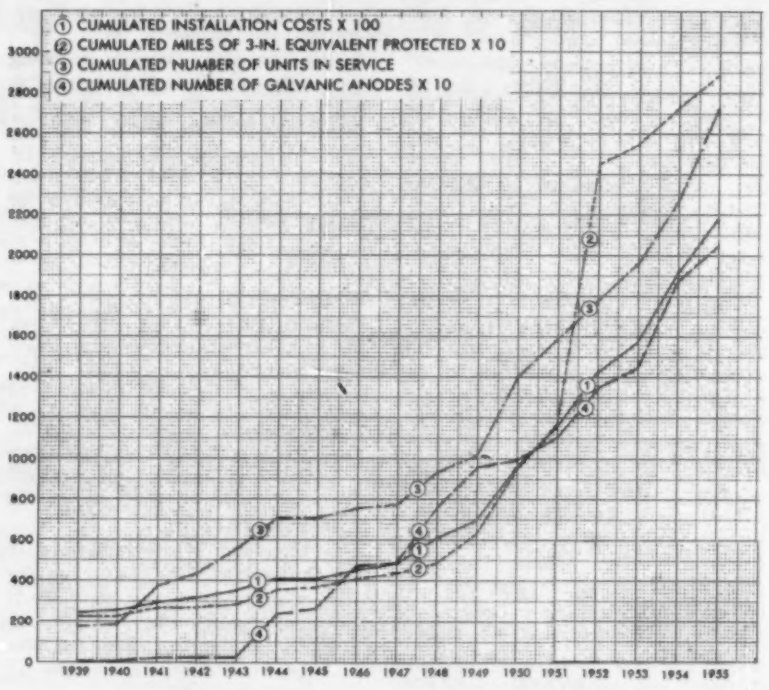

FIG. 1. Cathodic protection provided and installation costs for United's entire system, gathering and transmission.

*Presented at the 1942 Shreveport meeting of the Corrosion Section of PIEA, and published in the May, 1942, issue of THE PETROLEUM ENGINEER.

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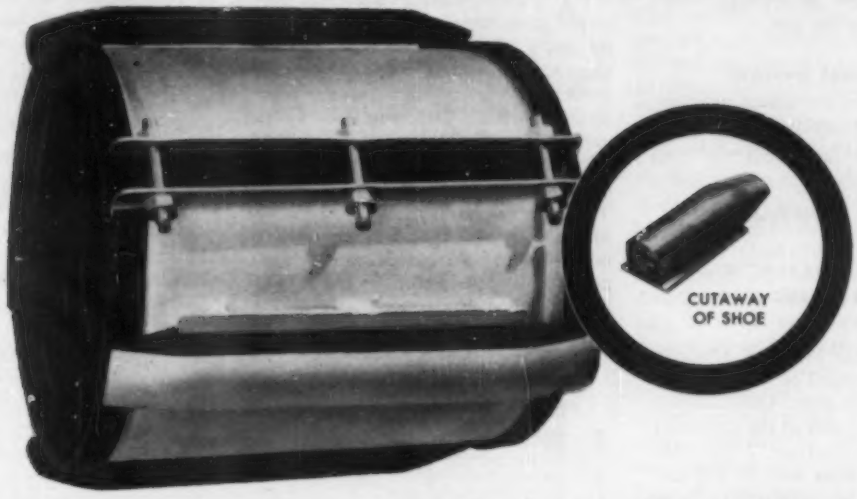
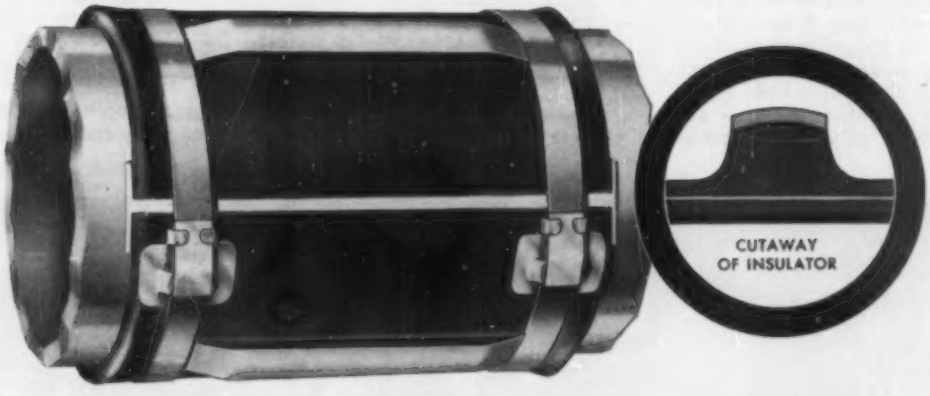


Model 56 Maloney Insulators for Small Jobs



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Model 55 Maloney Crossing Insulators, in all sizes through 36", are fitted with an extra-wide steel band for positive grip. Model 56, for pipe sizes through 12" with 2" nominal pipe size differential, are fastened to the carrier pipe with stainless steel bands. Both types offer greater dependability — greater protection against corrosion with high dielectric strength neoprene, and against physical damage with steel runners — than any other insulator on the market. Maloney Crossing Insulators are in use on most of the country's major pipelines.

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Progress — Total System

Fig. 1 shows the cumulated progress of this cathodic protection application program since 1939 with respect to:

1. Installation costs,
2. Miles of 3-in. equivalent pipe protected,
3. Number of units in service,
4. Number of galvanic anodes in service.

As of December 31, 1955, United's total system consisted of 42,558 miles of 3-in. equivalent pipe. About 28,841 miles, or 67.8 per cent of the total, was receiving protection from 2732 cathodic protection units and 20,565 galvanic anodes. The approximate total cumulated original installation costs for cathodic protection amounts to $2,193,211, or $76 per mile of 3-in. pipe protected. Total direct current drained is 28,317 amp. Total 1955 annual operation and maintenance costs including purchased electric power amounted to about $169,604. At the present rate of protection cost, it will take more than 700 years to spend as much as would be required to replace this pipe at present day prices.

Fig. 2 shows annual cumulated corrosion leaks repaired on the total system for a 16-year period. This curve is somewhat distorted because prior to 1948 we were unable to obtain complete reports on gathering lines where very little cathodic protection has been applied. For this reason, more total pipe is included during recent years. The two dotted lines show the estimated maximum and minimum rates of corrosion leak increase if no corrosion control measures had been carried out during this period. According to the minimum trend, the curve goes off scale in early 1947 with an annual rate of over 40,000. Of course, extensive pipe replacements would have been necessary before this large corrosion leak rate was reached. Total annual corrosion leaks on the system, exclusive of the Wichita Falls district and Mexican lines, which are no longer owned by the company, reached a peak of 4650 in 1948 and since then gradually dropped off to 2017 in 1955. There are still about 9563 miles of 3-in. equivalent bare unprotected pipe on the system.

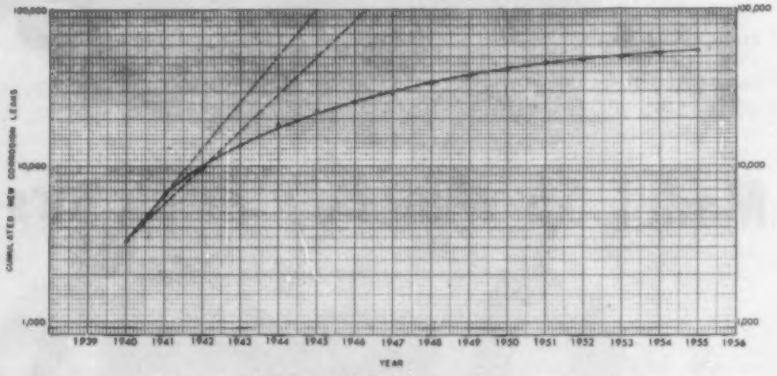
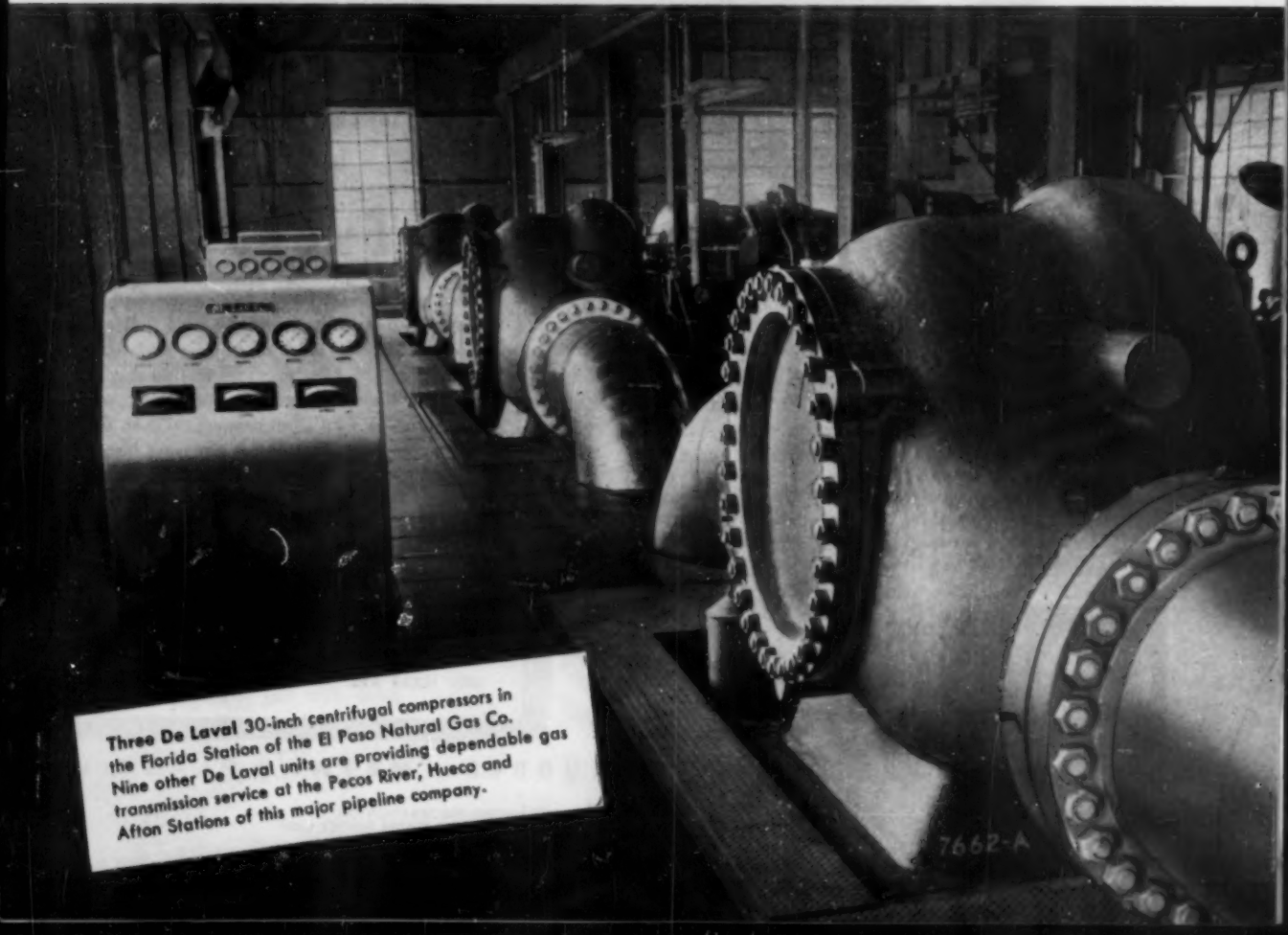


FIG. 2. Annual leaks repaired on system for a 16-year period.



Three De Laval 30-inch centrifugal compressors in the Florida Station of the El Paso Natural Gas Co. Nine other De Laval units are providing dependable gas transmission service at the Pecos River, Hueco and Afton Stations of this major pipeline company.

It is, of course, impossible to obtain accurate data regarding the amount of gas lost with each corrosion leak. Time lag between start of leak and repair, variations in operating pressures, and separations of unaccounted for gas due to other causes, introduce wide variations. With the assistance of the measurement department, however, studies have been made on selected sections of the system. At the present time, best information indicates that, with gas valued at 10 cents per Mcf, an average of $84 worth of gas is lost for every corrosion leak. On that basis, value of gas lost due to corrosion has been reduced from $390,600 in 1948 to $169,512 in 1955. The average cost of repairing corrosion leaks was $29.21 each in 1955 as compared with $11.57 in 1940. Other major benefits that cannot be figured accurately in dollars include increased operating safety, decreased right-of-way damages, and increased useful life of the pipe line system.

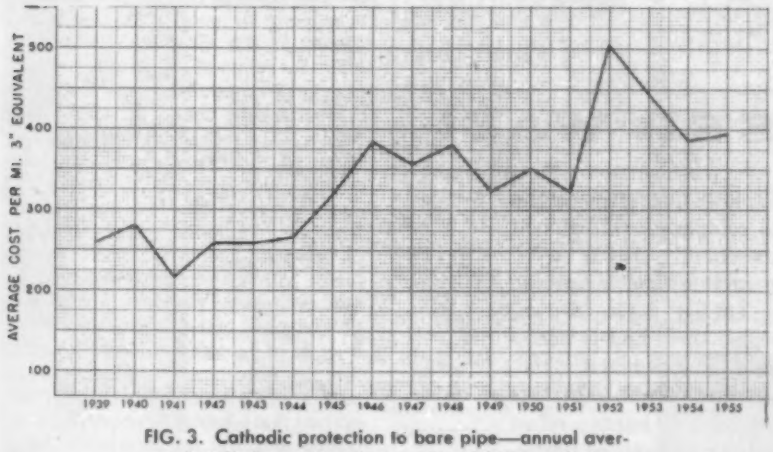


FIG. 3. Cathodic protection to bare pipe—annual average installation and cost per mile of 3-in. equivalent.

As of December 31, 1955, 1314 miles of 3-in. pipe owned by other companies was also being protected. This consists of sections of pipe in various areas in such close proximity to United lines that it is more economical to protect both companies' lines jointly. Each is covered by a standard "Cathodic Protection Co-ordination Contract." United's standard "Cathodic Protection Co-ordination Contract" form is practically identical to that recommended by the Correlating Committee on Cathodic Protection in its final report published by the National Association of Corrosion Engineers in July, 1951. In each case, installations are owned and operated by the company who is best situated to provide effective maintenance. Annual cost is shared in proportion to benefits derived. The first of these agreements was initiated with The Texas Company in 1940, and the others at intervals thereafter. Lou Scherer of The Texas Company and Dave Levy of Magnolia have contributed a great deal in past years toward the development of this type of cooperation.

Each of those contracts has functioned quite satisfactorily over a period of years for all companies concerned; unit costs are 30 to 35 per cent less than

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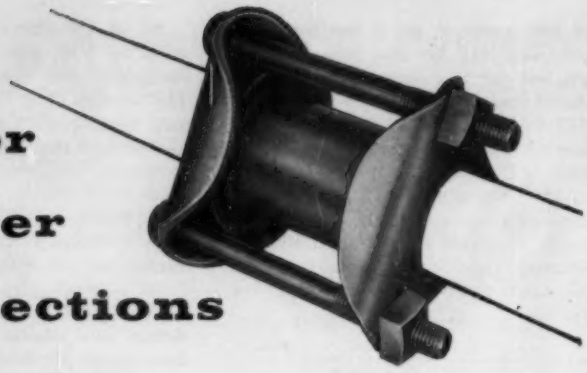

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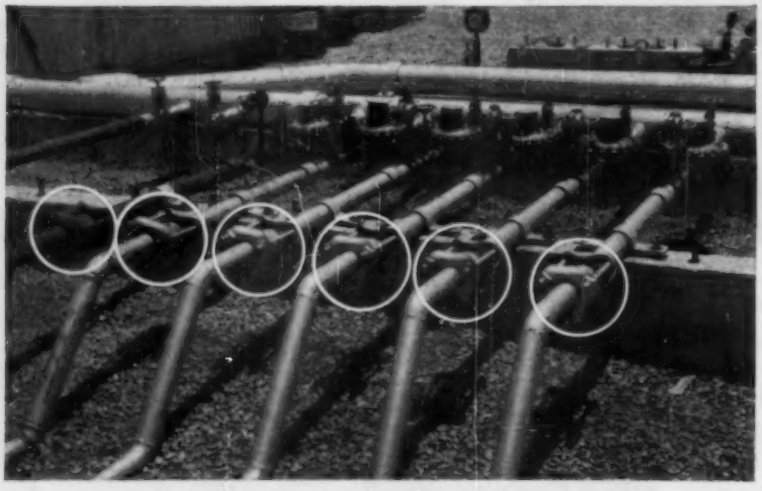

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if pipe lines involved were protected separately.

Coating Classification

These statistics are interesting in studying the overall system picture. They include protection on 5194 miles of 3-in. equivalent bare and 23,646 miles of coated pipe. Costs and application technique vary widely between bare and coated. For this reason we have analyzed all lines and classified each as to bare and coated. This was somewhat of a chore, as there are individual coatings that range from very, very poor to poor, fair, and good. Finally, it was decided to classify all lines that required less than 1 amp per mile of 3-in. equivalent to protect as coated and the rest as bare pipe. This results in a broad classification, as many of the newer lines with good quality coatings require less than 0.050 amp per mile of 3-in. equivalent. However, cathodic protection costs on coated lines do not vary directly with current requirements. In fact, even with a poor coating it is possible to apply cathodic protection for a fraction of the cost that would be necessary for bare pipe. As will be shown later in this article, it is extremely important that coatings be selected and installed that will maintain their effectiveness over long periods of time. It is realized that coatings on many of the company's older lines already have deteriorated to a great extent and it is only a matter of time before they will have to be classified as bare pipe. When that time comes it will be necessary to make large expenditures for additional cathodic protection if corrosion control is to be continued.

Coated Lines

There are 23,646 miles of 3-in. equivalent coated pipe protected on United's system, utilizing 295 units and 6671 galvanic anodes. Total current drained amounts to 3690 amp, or an average of 0.156 amp per mile of 3-in. equivalent. Total cumulated installation costs are $400,104, or an average of $16.92 per mile of 3-in. equivalent protected. Operation and maintenance costs, including purchased electric power, amounted to $36,586 in 1955. Average installation cost per ampere drained is about $108.

Designs, as well as operation and maintenance, are greatly simplified on coated lines as compared to bare line protection. A single relatively small rectifier unit, or a few galvanic anodes, usually will protect 10, 20, or more miles of large diameter pipe if all casings are insulated and good quality coatings carefully installed. In the case of long lines, electric power and suitable ground bed locations usually are

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Routes of El Paso Natural Gas Co.'s pipeline microwave systems in mountainous regions of Texas and New Mexico, and (below) microwave antennas on mountain.

RCA MICROWAVE assures the most advanced engineering features. Provision for the addition of future channels makes it the least expensive form of communication per channel mile. Equipment utilizes easy-to-service familiar circuits and conventional tubes. Single side-band suppressed carrier frequency division multiplexing is used exclusively to meet high standards of dependability. Frequency is controlled only from the terminals through the entire system. Furthermore, RCA provides the nation-wide services of the RCA Service Company to keep entire system operating at its peak.

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available at plenty of all-weather road crossings. Galvanic anodes frequently are economical where small currents are required. With low current densities used on coated lines, coordination of facilities with foreign lines is also greatly simplified.

For the last 6 or 7 years, it has been standard practice to coat all new lines and provide for cathodic protection in the original designs. During this period, cathodic protection also was applied on many of the coated lines that were laid prior to the time this policy was adopted. At present, only 4155 miles of 3-in. equivalent, or 15 per cent of the total coated system is not provided with cathodic protection.

Bare Lines

As of January, 1956, there were 5194 miles of 3-in. equivalent bare pipe protected, utilizing 2437 cathodic protection units and 13,894 galvanic anodes. The total current drained amounts to 24,627 amp, or 4.74 amp per mile of 3 in. Total investment cost on this bare pipe protection is $1,793,-107, or an average of $345.22 per mile of 3-in. equivalent as compared to $16.92 for coated pipe, a ratio of 20.4 to 1.

Fig. 3 shows average installation costs per mile of 3-in. for each year during this 17-year period. Except for a few small isolated jobs, all construction work was done by contract with United supplying material and engineering. It is interesting to note that unit installation costs increased from a minimum of $216 in 1941, to $506 in 1952, an increase of only 134 per cent. At first thought this would appear in error, as it is common knowledge that, in general, material and labor costs have increased much more rapidly. Introductions of more efficient methods of doing work, as well as availability of improved types of construction equipment, have contributed toward holding down unit costs. For example, in the early forties, we were paying 90 cents to $1.00 per ft for drilling ground bed holes whereas present prices are 40 to 50 cents. In our design studies, we have always tried to make changes that would reduce field costs wherever possible without lowering the standard of results. Other variations are due to volume of work on individual contracts and distance between individual jobs. The increase in 1952 was due to smaller volume of work and few contractors available for bidding.

The total cost for purchased electric power, operation, and maintenance on bare pipe protection in 1955 amounted to $133,018.

Rectifier units usually are used for bare pipe protection because, with relatively large volumes of current required, unit costs are almost always lower. Galvanic anodes frequently are used on small diameter pipe or very short sections of large pipe when electric power is not available.

From 3 to 8 rectifier units ordinarily are required per mile of bare pipe, depending on diameter of pipe, soil conditions, and local circumstances. This frequently requires building electric distribution lines along pipe line in order to get low cost electric power available where needed. On long sections a single-conductor 2400 or 7200-v circuit customarily is used with step-down distribution transformers at convenient points serving a 120-v conductor. Where there are telephone lines along right-of-way, it is standard practice to overbuild such circuits with electric power lines. The first of such type of installations was made in 1941 and our inductive coordination practices have been quite successful.

As the number of units per mile of pipe increases, the availability of alternate ground bed sites decreases rapidly. Hence, right-of-way purchasing becomes much more involved for bare pipe. Many of the old bare lines utilize dresser couplings, which require installation and maintenance of elec-

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trical bonding in connection with cathodic protection.

With the high current density required for bare pipe, coordination problems with nearby foreign lines become more complicated. Where foreign lines parallel us closely, it frequently is impossible to protect our line without supplying considerable protection to the other company's lines or line. Where the other company is ready to cooperate and share expenses this problem is eliminated and unit costs to both are reduced. Where the foreign company is not sold on this type of protection, it is necessary to supply a considerable amount of free protection or postpone the use of cathodic protection. During recent years, the number of companies that have become enthusiastic about the use of cathodic protection has grown very rapidly.

Forecast

At present, there are still 9563 miles of bare and 4155 miles of coated 3-in. equivalent pipe on United's system that has never been provided with cathodic protection. A large percentage of this bare pipe already has been in the ground 25 years or more. In 1955, 2017 new and 660 old corrosion leaks were repaired at a total cost of $78,183 ($29.21 per leak). Old corrosion leaks usually mean replacement of rubbers or tightening clamps that had been installed at a previous date.

United has accumulated a great amount of data regarding soil characteristics and physical conditions of its pipe. Much of the pipe, particularly the bare pipe, is seriously corroded. If corrosion leaks and pipe replacements are to be controlled within reasonable limits, it will be necessary to install considerable additional cathodic protection on the balance of this bare pipe in future years. Existing coated pipe installations may also require increased cathodic protection capacity when and if existing coatings deteriorate, calling for additional drainage.

During the past few years, we have had a few blowouts caused by uniform general corrosion over relatively large areas of pipe surface. Inspections of these sections of pipe showed no pitting and, as the original surface of the pipe had entirely disappeared, it was impossible to detect the seriousness of corrosion from an external inspection. This type of corrosion is, of course, very unusual but we have been wondering if similar conditions are not developing at a few other points on our old bare pipe system. We have been trying to develop a method for detecting such conditions with little or no success to date. X-ray and various other non-destructive methods of measuring wall thickness have been investigated. As each of these methods check only a very small area per test, they do not appear practical for this purpose. The only alternative seems to be pressure testing and/or cutting pipe at selected points, which is, of course, quite expensive. We hope a less expensive and more practical method will be available in the near future.

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★ ★ ★

Table 1

Item	Bare pipe	Coated pipe	Total system
Miles of 3" equivalent in service	14,757	27,801	42,558
Miles of 3" equivalent protected	5,194	23,646	28,841
Per cent of pipe protected	35.2	85.1	67.8
Miles of 3" equivalent unprotected	9,563	4,155	13,717
Number of units in service	2,437	295	2,732
Number of galvanic anodes in service	13,894	6,671	20,565
Total d-c amperes drained	24,627	3,690	28,317
Amperes drained per mile of 3" equivalent	4.74	.156	—
Total installation costs	$1,793,107.00	$400,104.00	$2,193,211.00
Installation cost per mile 3" equivalent	$ 345.22	$ 16.92	$ 76.00
1955 operation and maintenance costs	$ 133,018.00	$ 36,586.00	$ 169,604.00
1955 total operation and maintenance per mile 3"	$ 25.61	$ 1.55	$ 5.88

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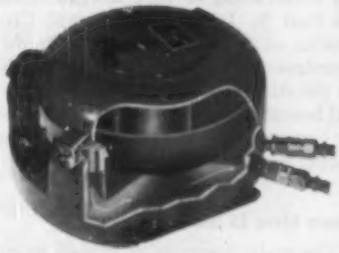

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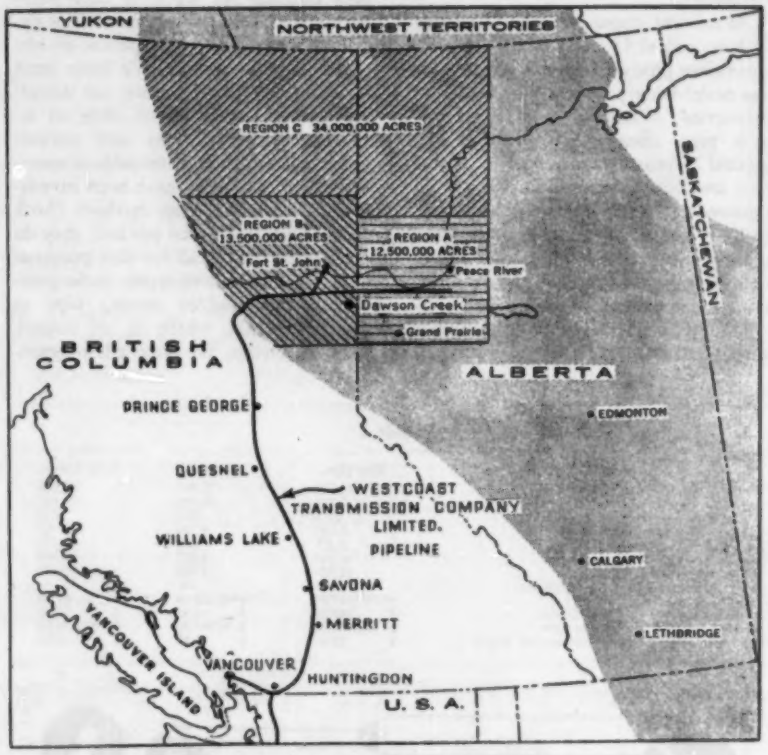
Ahead of construction schedule, first gas will be delivered in November, 1957—80 per cent of route is through heavy forests

Leslie Orr Rowland

CANADA'S first major natural gas pipe line is being laid ahead of schedule and will meet comfortably the deadline of November, 1957, for first deliveries of natural gas to Vancouver, British Columbia, and across the international boundary at Sumas, British Columbia. At the latter point large quantities will move into the export market for use in Pacific Northwest states.

The owner and operator is Westcoast Transmission Company, Ltd., a Canadian company formed by Pacific Petroleums, Ltd., largest owner of natural gas reserves in northeastern British Columbia where the Westcoast line originates.

An extensive gathering system is being constructed to pick up gas from the Fort St. John field of British Columbia, an exclusive preserve of Pacific Petroleums, and from a group of fields on the Alberta side of the interprovincial boundary, where various other major companies and operators as well as Pacific Pete.



Map showing Sedimentary Basin area in British Columbia and Alberta.

Main Line Is 30-in.

The main line consists of 649 miles of 30-in. pipe. Purchase of about half the pipe in the United Kingdom, with delivery through the Panama Canal to Vancouver, has made the construction project somewhat independent of the steel strike in the United States, and deliveries have kept well ahead of pipe laying by a three-way transportation utilizing barges, railway, and trucks from Vancouver to field stockpile points.

Four large contractors were awarded the construction jobs by Canadian Bechtel, Ltd., engineer and project manager for the line. Dutton-Williams Brothers, Ltd., of Calgary, Alberta, has the first section, starting at Taylor Flats, near Fort St. John, where the initial compressor station will be located, and running to a point below the western approach to Pine Pass where the route of the lines crosses the Continental Divide at the second highest elevation reached in the 649 miles, nearly 3000 ft. This section consists of 120 miles. Orville "Red" Graves is spread superintendent.

The Dutton-Williams spread is moving southward on its construction schedule, but each of the other three spreads started at the south end of its section and is moving northward.

The second section was awarded to Canadian Bechtel, Ltd., which kicked off at a point 20 miles north of Williams Lake in the British Columbia interior and will finish at the point where the ascent of Pine Pass starts. Here it will tie in with the termination of the Dutton-Williams section. Its distance

is 210 miles. Mike Finnerty is spread superintendent.

The third section is being laid by Conyes Construction Corporation of San Pablo, California, and consists of 209 miles, running north from a point about 10 miles south of Merritt and terminating at the point of commencement of the Bechtel section. Harlan Evans is spread superintendent.

The fourth section, awarded to Mannix, Ltd., of Calgary, begins at the Sumas compressor station, traverses the lower Fraser Valley and runs half the length of the Coquihalla Canyon, and all the Boston Bear Creek Canyon, where it encounters the most rugged and difficult terrain of the entire project, terminating near Merritt not far beyond the upper end of the canyon. This section contains 110 miles. Fred Byers is the spread superintendent.

Pipe Delivery Major Operation

Pipe delivery has been a major operation throughout the job, except for the lower Fraser Valley. The end of steel on the Pacific Great Eastern Railway at Prince George is about half-way along the route of the line, so all pipe has been moved by stringing trucks north from this point. Out of Vancouver the pipe has been loaded onto railway barges to cross the Howe Sound to the railway company's terminus at Squamish, British Columbia, where it is made up into trains. Extra loading has been avoided by putting the pipe on flat cars on the barges, but this has involved special handling to avoid possible shifting of loads on the sometimes rough stretch of water. The railway line was extended recently into North Vancouver and this will make it possible for future pipe shipments to be made direct by rail all the way.

At the Prince George terminus the pipe is being double-jointed into 80-ft sections in a field yard a few miles north of the town. The joints are loaded onto extra long and heavy stringing trucks for delivery to various stockpiling points along the right-of-way both north and south from Prince George.

Dutton-Williams Spread

The Dutton-Williams spread has pushed its work along at a pace of about a mile a day, through a region that begins with a considerable mileage of muskeg and continues into rock as it mounts the east slope of the pass. Steep side hills in the mountainous section are frequent and rainy weather slows down machines to a crawl. Tie-in welds on several occasions have been made under a canvas shield to keep the work going ahead through the rain.

One portion of this section involves

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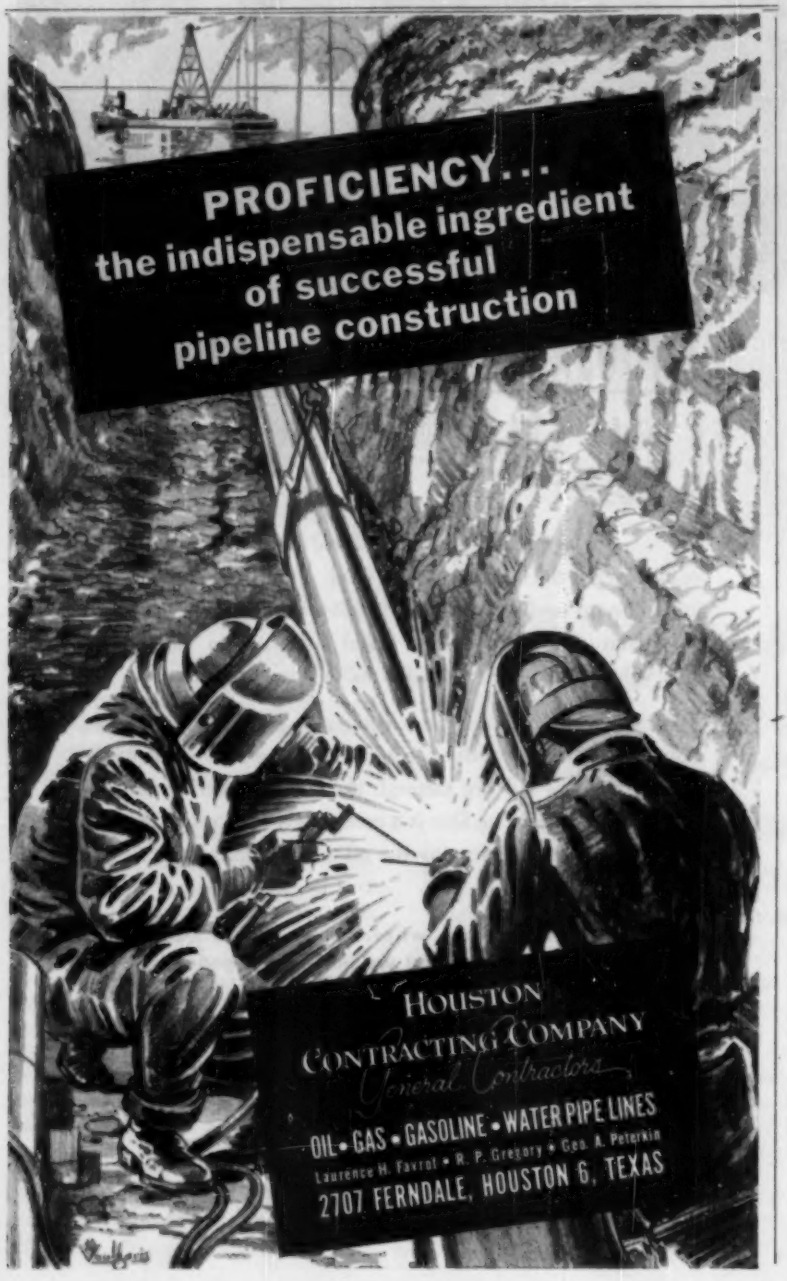
13 crossings of the Pine River, which meanders back and forth across the right-of-way up the east side of the pass. These crossings, all buried, have been made with weighted pipe. Including other crossings, this section will require a total of 1800 concrete river weights of the split collar type.

Considerable ditch has been cut by backhoes on this spread, both in the muskeg and in the mountainous areas, but conventional ditchers have been used when convenient even in short stretches of a few hundred yards, sometimes being winched up or down steep slopes.

The spread has had up to nine backhoes working at one time, along with two medium ditchers and a large ditcher than can dig some light rock. The dope gang is cradling the pipe over the ditch as much as possible. In some cases mud has made it necessary to skid the wrapped pipe, and in these places the tie-in gang lowers in.

The pipe gang is equipped with tracked trailers towed by large tractors for the three 300-amp stringer bead welding machines and four 300-amp hot pass machines, which are mounted in pairs on two carriers. Ten welders are on the firing line. Top footage of 7000 ft a day has been logged by all crews and the dope gang has shut down early a few times after wrapping this much footage and running up on top of the welders.

The Dutton-Williams spread is the only one operating almost entirely remote from living accommodations and has set up the most elaborate trailer camp ever seen in Canadian pipe line construction. Consisting of 89 trailers, the entire camp was built to the contractor's specifications, and is housing a maximum of 600 men. The camp is fully mobile and made its first move from Dawson Creek to Milepost 79 in a single day.



Bechtel Spread

The Betchel spread has the most nearly level part of the line, along the Upper Fraser River Valley and the Crooked and Misinchinka River valleys. This section, however, has a large amount of swamp in patches and a number of steep hills in rolling wooded country. Nine large tractors are being used by the right-of-way crew. The bending crew has made as many as 80 per cent bends in some stretches and has averaged 100 bends per day, up to 43 deg for overbends and sags and as sharp as 48 deg on side bends.

The large conventional ditching machine on this spread is equipped with a special set of heavy tracks for working in muddy ground. A large proportion of the terrain is heavy, fairly impermeable soil, which holds water and is slow to dry after rain. Right-of-way that would support an ordinary passenger car when dry was found to bog down the dope gang machines to the tops of their tracks when wet.

Pipe gang machines are track-mounted for easiest travel over the soft and muddy ground, and four sideboom pipelayers are being used on the dope gang.

Conyes Spread

The Conyes section traverses some wild country through the south-central British Columbia, with some exceptionally steep grades and a considerable amount of rock interspersed with swamp and bog. The bending gang has been busy on this spread, too, making up to 110 bends in a day. Stringing has involved some long-distance hauling because of an extreme scarcity of roads in the southerly sector for some 80 miles. One long slope of almost 45 deg is traversed for a distance of nearly half a mile. Deadman Canyon, a stretch of 15 miles, provided one of the most difficult pipelaying jobs. The northerly 125 miles is accessible from the main highway and the railway.

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Mannix Spread

The Mannix spread has the most rugged portion of the whole route, where it goes through the entire Coquihalla Canyon, and most of this section will have to be left for the 1957 construction season as snow is deep in the high altitudes where the right-of-way climbs up to its maximum of 4700 ft going over Boston Bar Pass. By using this pass through the Boston Bar Creek canyon the line will bypass the tough north end of the Coquihalla Canyon, which was used by the Trans Mountain oil pipe line, but as a construction job it imposes a section of pipelaying through country that lacks both road and railway.

Total canyon construction on this spread, mostly rock work, is 40 miles. Almost as difficult was the initial 12 miles from Sumas compressor station across Sumas Swamp. The water table is on the surface, as this diked and reclaimed land lies 12 ft subsea. Every foot of this sector had to be well-pointed to hold the ditch in place long enough to get the pipe into the ditch, and every foot of pipe had to be river-weighted.

Equally difficult terrain was the ascent and descent of Agassiz Mountain, at the east end of the lower Fraser Valley, where there were two jumpoffs of 25 deg, the 600-ft Agassiz Mountain section and the 2800-ft Angel Mountain section.

Heavy timber is a feature of every section of the Westcoast line, and Westcoast engineers estimate that 80 per cent of the total mileage is through such timber. Timber has been cleared well ahead of the pipe-laying, by a specialist subcontractor with long timber-cutting experience. The cut timber has been useful in many sections for rip-rap over muskeg and swamp.

Coating and wrapping has been of two types: Wax-base dope with single wrap of inner coat and kraft paper outer wrap, and ordinary asphalt dope with inner glass fiber wrap and outer asbestos felt.

The scheduled completion date for first delivery of gas is November 1, 1957, and indications are that this deadline will be met comfortably. Four compressor stations to be installed initially will provide capacity of 400,000,000 cu ft a day and ultimate capacity of 660,000,000 cu ft a day will be achieved with a total of 9 compressor stations. Westcoast has a firm contract for 290,000,000 cu ft a day initially, increasing to 382,000,000 cu ft a day in the heating season of 1959-60. Both are minimum quantities and probably subject to substantial increases even before they begin. ★ ★ ★

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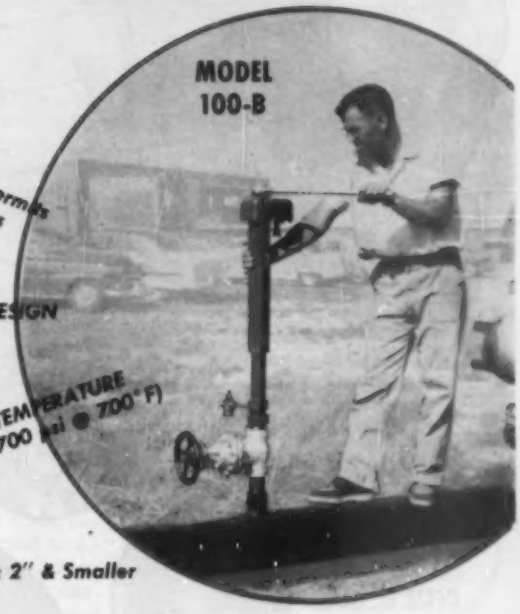
TAPPING MACHINE



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Three other sizes of WmSON-HILLCO Tapping Machines

MODEL 360
Taps to 6"—Hand operated

MODEL 660
Taps to 16"—Power operated

MODEL 1200
Taps to 36"—Power operated

MAXIMUM RATING, EACH MACHINE: 1,440 psi @ 100°F or 700°F @ 700 psi

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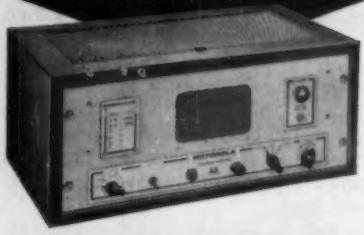
* Tone-activated for protection from false alarms



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FAIL-SAFE INDICATION—An *extra* and *separate* alarm system within the monitor warns you of non-standard operation. The "fail-safe" light gives you 3-way protection, alerting you to (1) abnormally weak received signal, (2) complete absence of carrier, or (3) non-operative receiver.

CRYSTAL-CONTROLLED CHANNELS—Up to 5 crystal-controlled channels, including the two Conelrad frequencies, give you positive assurance that your monitor will always be on frequency. No need to worry about excessive heat or aging components detuning your receiver. An additional channel is tuneable over the broadcast range.

JUST SET IT, FORGET IT...

Just turn the power on, and select the channel. Then forget it! The dispatcher needn't turn it off every time he goes off duty, because the alarm on a Motorola Conelrad Monitor *can't* be set off by a routine station break.

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Pipe Line Projects

Transco to Build 99 Miles of Additional Line

Transcontinental Gas Pipe Line Corporation, Houston, Texas, has announced a proposal to build an additional 99 miles of pipe line costing approximately $12,358,000 to augment the company's line now under construction to provide for additional service. This project when completed with construction now in testing stages, would increase Transco's daily delivery capacity by about 126,000,000 cu ft of natural gas per day.

FPC has granted temporary authority to operate new pipe line facilities to make available to one new and 18 existing customers a total of approximately 49,000,000 cu ft of gas per day.

The Commission last July granted temporary authority to Transcontinental to construct the facilities to provide this additional service. The facilities are part of a larger project proposed by Transcontinental in an application which is still pending before the FPC.

The facilities being constructed under the temporary authorization granted last July include a total of approximately 252 miles of pipe line on the company's system in Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland, and Pennsylvania, and an additional 12,750 hp in compressor capacity. Total estimated cost is $38,500,000.

In granting the temporary authorization for operation of the facilities, the FPC limited Transcontinental's deliveries to two of its existing customers so that sufficient gas would be reserved for service to those distributors and communities which the Commission may ultimately find should be served through the facilities. The FPC said, that in order that Transcontinental may not inadvertently make commitments from which it might have difficulty in withdrawing, the temporary authorization was being conditioned to provide that additional deliveries to Piedmont Natural Gas Company, were to be limited to a maximum of 1,608,000 cu ft per day, rather than the proposed 5,000,000 cu ft; and that the additional deliveries to Public Service Company of North Carolina were limited to 2,625,000 cu ft daily, whereas Transco had proposed 3,000,000 cu ft per day.

FPC also permitted Transcontinental to build the sales and delivery facilities necessary to render the additional service during the 1956-57 winter heating season.

New Products System West Texas to Gulf

Gulf Oil Corporation has under construction a products pipe line system from West Texas to the Gulf Coast area. As part of the system Gulf will convert an old 10-in. crude oil line that extends from Midland to Lufkin. A new 46-mile line will be laid from Midland to Gulf's natural gasoline plant at Waddell in Crane County. A new line will be laid from Gulf plants in southeast New Mexico to tie-in at this point. On the other end of the system a new 125-mile line will be laid from Lufkin to a distribution terminal at Barbers Hill.

West Texas-Gulf Coast Crude Line Said Planned

What is considered to be a reliable source states that plans are underway to build a large-diameter crude oil line from West Texas to the Gulf Coast. Several major companies are said to be behind the proposal, which would have a capacity of 250,000 to 300,000 bbl a day.

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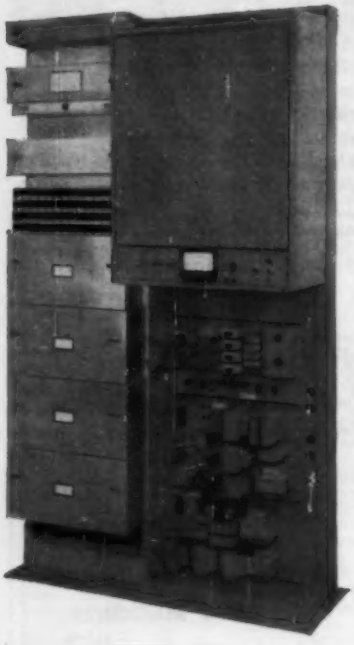
PHILCO Series 500

Philco Series 500 Package is designed primarily for pipe line and railroad companies requiring maximum dependability consistent with highest commercial performance standards along extensive right-of-way routes.



FEATURES

- Expandable to 24 or more channels (plus service channel)
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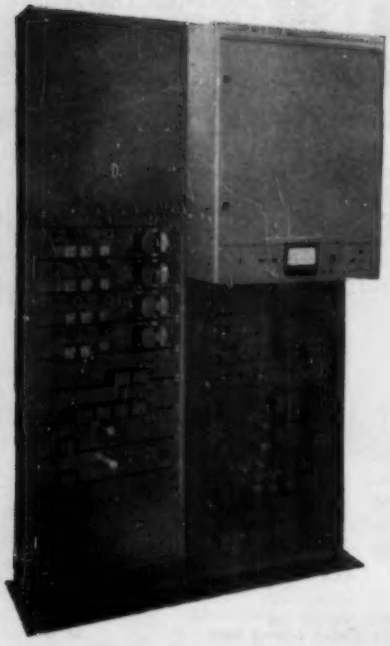

PHILCO Series 120

Philco Series 120 Package is designed to provide low cost, reliable communications over moderate distances for turnpikes, police, and utilities.

FEATURES

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- Extendable to 10 hops
- Commercial quality circuits

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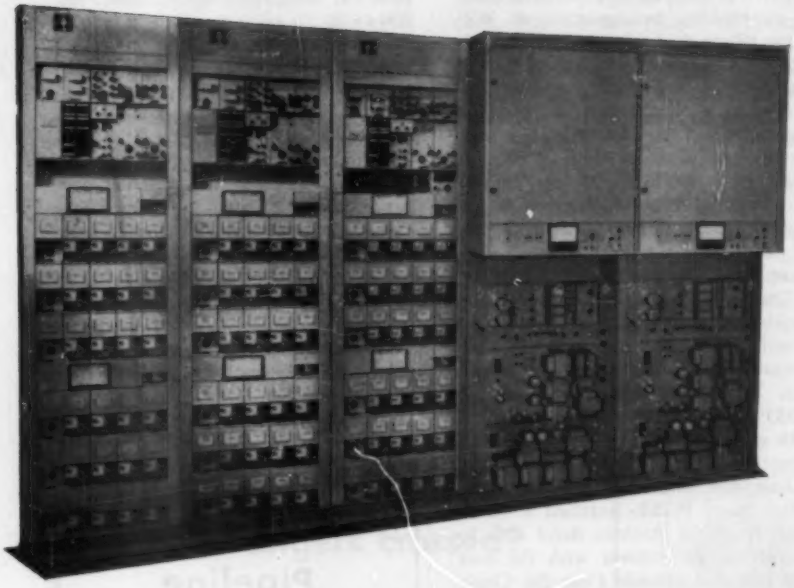

PHILCO Series 90

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Projects

West Sacramento Valley Gas Line Started

Work has been started on a 5,250,000 steel pipe line, 83 miles long, that will bring up to 40,000,000 cu ft more natural gas from the Beehive Bend field near Willows into the Sacramento (California) area daily, Pacific Gas and Electric Company has announced.

Main contract for pipe line installation has been awarded to Engineers Limited Pipeline Company, according to Norman R. Sutherland, PG&E president and general manager. Completion is scheduled for next summer.

Equipment is being moved into the Beehive Bend area, and the contractor is establishing headquarters at Williams, where probably 100 men, including 10 from PG&E, will remain for the first part of the project.

Known as the "west side line," the big barrel will have an 18-in. diameter for the first 37 miles south of Beehive Bend, then a 20-in. section for the second 37 miles to a point east of Davis, and 16-in. from there to Sacramento. A submarine crossing of the Sacramento River will have two 12-in. pipes.

The route passes near Williams, Arbuckle, Dunnigan, Zamora, Yolo, and Woodland. It will complete a "loop" around the Sacramento Valley and this, Sutherland noted, will enable PG&E to operate its gas facilities there with greater flexibility as well as with greater capacity.

Last year, in another step toward the valley loop, PG&E installed a 12-in. main from the Beehive Bend area to Marysville, to connect with the east side line that extends from the Chico area to Sacramento via Marysville, Lincoln, and Roseville.

The Perkins Lake, Llano Seco, and Willows fields, recent developments near Beehive Bend, will be connected to both the east side and west side transmission lines in the near future, Sutherland said.

Texas Gas to Build 13-mile Louisiana Line

Texas Gas Transmission Corporation, of Owensboro, Kentucky, has been granted FPC temporary authority to construct and operate $1,459,000 in natural gas transmission facilities in Louisiana.

Texas Gas proposes to construct 13 miles of 20-in. pipe line extending from the end of its East Lake Palourde 20-in. line in Assumption Parish to the Thibodaux area.

Texas Gas does not propose to serve any additional markets with these facilities. They will be used to receive additional gas reserves dedicated to Texas Gas for resale to present customers.

Tennessee Gas Plans $166,830,000 Program

Tennessee Gas Transmission Company plans construction of 1085 miles of natural gas pipe line and compression units aggregating 117,240 hp at an estimated cost of $166,830,000. Application has been filed with the Federal Power Commission.

Tennessee Gas proposes to increase the average daily delivery capacity of its system by 456,408,000 cu ft. This increase, plus other increases still pending FPC action, would result in an average daily sales capacity of Tennessee's system of 2,471,701,000 cu ft and a peak day sales capacity of 2,886,076,000 cu ft.

Tennessee proposes to construct 1085 miles of line in Louisiana, Mississippi, Alabama, Tennessee, Kentucky, West Virginia, Pennsylvania, New York, and to fields in the Gulf of Mexico off the Louisiana shore. The company also proposes to construct new compressor stations in Mississippi, Tennessee, Pennsylvania, and New York totaling 53,700 hp, and plans to add 63,540 hp in existing stations in Tennessee, Kentucky, Ohio, and Pennsylvania.

A second submerged pipe line crossing of the Mississippi River near Greenville, Mississippi, is also planned.

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Two California Storage Fields Now in Service

TWO Southern California underground gas storage projects, representing an investment of more than $25,000,000 have been placed in full operation for the area's expanded winter heating demand.

The projects are the Southern California Gas Company's $15,000,000 storage field at Playa del Rey and the Pacific Lighting Gas Supply Company's $10,300,000 Montebello field.

The two natural gas storage facilities will form important links in the integrated transmission and storage system that serves customers of both Southern California and Southern Counties Gas Companies.

The Montebello project is the newest of the four Southern California projects, the second largest in California and one of the five largest in the world. Construction at this field, including installation of six 1350-hp compressors, began in January, 1956.

The del Rey field has been in operation as a gas storage reservoir since 1942. It was owned by the Federal Government and operated by the Southern California Gas Company until 1953, when the gas company purchased the property. Despite its relatively small present working storage capacity of 1.3 billion cu ft, it is still more than a hundred times larger than the largest man-made holder.

The other two area fields are in East Whittier and in La Goleta near Santa Barbara. Both are owned by Pacific Lighting Gas Supply Company, an affiliate of Southern California and Southern Counties Gas Companies. Goleta is the largest of the four, although its operating capacity is nearly equalled by the Montebello project.

Each field performs particular functions. The del Rey project is utilized primarily to meet hourly and daily peak demands. Thus gas stored in these projects during early morning "off peak" hours may be withdrawn later the same day for use when demand is high.

The Goleta field, by contrast, is used essentially to meet seasonal demand, with gas being stored during the summer and withdrawn during the winter. Montebello is a combination of the two, being close enough to the demand center to be used for daily peaks and to provide seasonal storage.

Current work at dey Rey, now in its final stages, includes reconditioning of 29 producing wells, modernization and beautification of the well sites, enlarging the compressor station, office building and cooling tower.

Withdrawal capacity of the reservoir has been doubled by this work to 20,000,000 cu ft per hour. This capacity will be increased in stages up to 27,000,000 cu ft per hour, probably by the winter of 1961-62.

With completion of construction at Montebello, working capacity will be about 12½ billion cu ft, with a daily injection rate of 60,000,000 cu ft per day and withdrawal capacity of 200,000,000 cu ft per day.

These new and expanded storage fields are required to match the continued development of the Southern California area, growing at a rate of 100,000 new gas company customers a year. With this residential growth has been an accompanying expansion of commercial and industrial establishments, which likewise require an increasing supply of immediately available natural gas.

Do you keep your fingers crossed?

— every time you start one of your gas engine driven compressors? Many a starting air piping system has been blown into shrapnel by a lubricating oil vapor explosion. The possibility of this can be obviated by installing a Campbell Centrimpact separator. Price, $300.00, f.o.b. Long Beach, California. This is not a filter but a combination of centrifugal and impact design which throws out the finest mist particles and isolates them from the flow. We can state without fear of contradiction that CENTRIMPACT IS THE MOST EFFICIENT MIST EXTRACTOR EVER BUILT.

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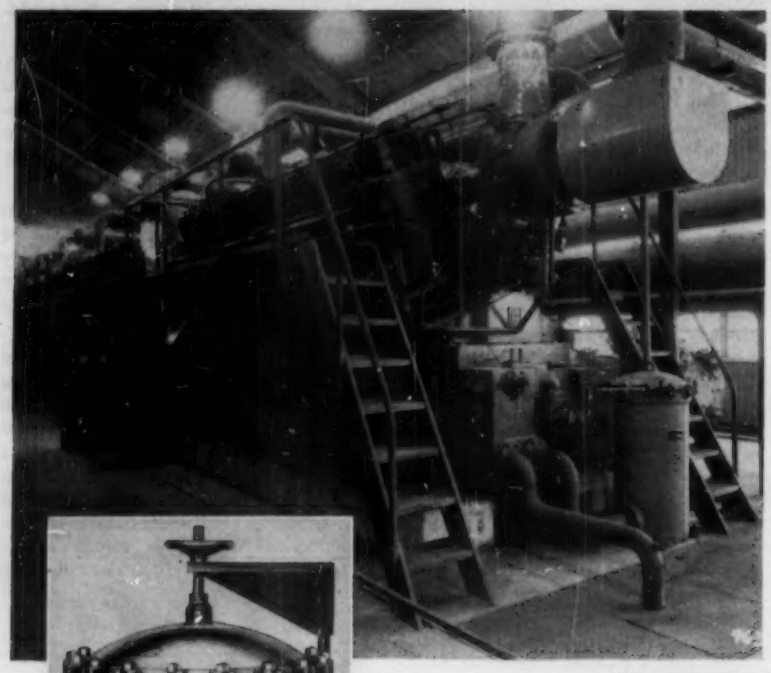

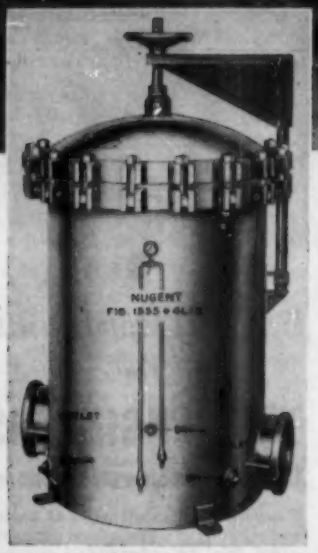

Nugent 1555 "Extended Area" Filter of the type used by El Paso at Midkiff. These filters are equipped with laminated crenulated fiber disc recharges which have had an average life of 2500 engine hours at the Midkiff Station. They remove solid particles as small as 2 microns but do not remove additives in detergent oils. Recharging requires only ten minutes.

Nine Ingersoll-Rand turbo-charged gas engine driven compressors at the Midkiff Station of El Paso Natural Gas Co. have been equipped with Nugent Filters since installation. The full-flow filtering provided by these filters has protected the bearings and kept these engine-compressors clean inside for well over two years. Service like this has resulted in many repeat orders from El Paso Gas Co. and other leading pipe line companies.

To give your engines and compressors the protection they deserve, specify Nugent Full-Flow Filtering. This means that *all* the oil in circulation passes through the filter every cycle before going to the bearings . . . and it means that particles as small as a few microns are removed before they can damage precision parts. Write for helpful descriptive literature today.

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PIPE LINE PERSONALS

▸ **Glenn W. Clark** has been elected president and a director of the Mississippi River Fuel Corporation, St. Louis, Missouri. He succeeds **William G. Marbury,** who becomes chairman of the board and remains as chief executive officer. Clark has been president of Cities Service Gas Company and Cities Service Gas Development Company.

▸ **George W. Anders** has been appointed director of public relations for Texas Gas Transmission Corporation, Owensboro, Kentucky. He will be in charge of the company's public relations, financial relations, publications, and advertising. Prior to joining Texas Gas, Anders was assistant manager of public relations for Texas Eastern Transmission Corporation.

G. W. Anders

E. R. Thomas

▸ **E. Rue Thomas,** Houston engineer and attorney, has joined Trunkline Gas Company as superintendent of gas supply. Thomas has been with Humble Oil & Refining Company, where for the last nine years he has served in various engineering capacities in the firm's gas department. His experience includes engineering work in the fields of natural gas system and gasoline plant design and operation, gas sales contracting and work with the legal department on Federal Power Commission regulatory procedures.

▸ **George F. Russell** has been elected assistant comptroller of the Service Pipe Line Company. He succeeds **James L. "Jerry" Donovan,** who is retiring after 38 years' service.

Previously employed by the Vulcan Steel Tank Corporation, Russell joined Service Pipe Line in 1935, as head of the special studies section.

Also announced was the appointment of **J. J. Willenburg,** Galesburg, Illinois, as manager of the Missouri and Illinois divisions of Service Pipe Line. Willenburg, with the company since 1922, has been manager of the Illinois division with headquarters at Galesburg.

H. C. Jones, Raytown, Missouri, retired as former manager of the Missouri division and Willenburg assumes direction of both divisions. To assist him in the management of the two divisions, **G. L. Maciula,** Galesburg, assistant manager of the Illinois division, will be transferred to Raytown to assume the supervision of the Missouri division. He has been with the company since 1946.

▸ **K. G. Smith** has been named to succeed the late **J. L. Copeland** as district superintendent of Interstate Oil Pipe Company at Magnolia, Arkansas. Smith has been serving, since September 1, as assistant district superintendent of the Magnolia district.

WITH THE

PIPE LINE CONTRACTORS

● **Dutton-Williams Bros., Ltd., North Canadian Oils Building, Calgary, Alberta.** Has 120 miles of 30-in. line for *Westcoast Transmission Company, Ltd.* between Taylor and Azouetta Lake, British Columbia. Has 87.3 miles of 34-in. line for *Trans-Canada Pipeline*, to begin in 1957. Has 38 miles of 8 and 6-in. line for *British American Oil Company* between the Fenn area and Stettler and between the Nevis area and Stettler, Alberta. Has 320 miles of 10 through 4-in. distribution systems for *Inland Natural Gas Company* in Nelson, Savona, and Penticton, central British Columbia. Also has 12 through 4-in. gathering system for *Rangeland Pipeline Company* between Red Deer and Rimbey, Alberta.

● **O. R. Burden Construction Corporation, 6702 East Twenty-first Street, Tulsa, Oklahoma.** Has 90 miles of 8-in. line to take up and recondition for the *Ohio Oil Company* between Teutopolis and Martinsville, Illinois.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 252 miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming.

● **Trojan Construction Company, Inc., 1416 N. Robinson, Oklahoma City 3, Oklahoma.** Has contract for takeup and reconditioning 276 miles of 8-in. line for *Sinclair Pipe Line Company* between Jacksboro and Mexia, Texas.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 246 miles of 30-in. natural gas line from Hancock County, Indiana, to Slaughters, Kentucky, as part of a joint venture with Houston Contracting Company on 783 miles of 30-in. for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas state line near Eudora, Arkansas. Also has 82 miles of 26-in. line for *Tennessee Gas Transmission Company* near Chauncey, Ohio.

● **Sheahan Pipe Line Construction Company, 514 National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 90 miles of 14-in. to lay, 75 miles of 8-in. take-up for *Sun Pipe Line Company* between Marcus Hook, Pennsylvania, and Plainfield, New Jersey.

● **Missouri Valley Dredging Company, 222 William Street, Omaha, Nebraska.** Has three major crossings on *Sun Pipe Line Company's* 109-mile new products line between Twin Oaks, Pennsylvania, and Newark, New Jersey; the crossings are on the Schuylkill, Delaware and Raritan rivers.

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **Mannix, Ltd., 332 7th Avenue W., Calgary, Alberta.** Has 110 miles of 30-in. gas line at the south end of *Westcoast Transmission Company's* gas line from Peace River area, Alberta, to U. S.-Canadian border near Vancouver, British Columbia. Has 90 miles of 34-in. gas line for *Trans-Canada Lines, Ltd.*, between Moose Jaw and Wolseley, Saskatchewan.

● **Oklahoma Pipe Line Contractors, 6612 Hines Blvd., Dallas 20, Texas.** Has 327 miles of 18-in. line for *Plantation Pipe Line Company* between Baton Rouge, Louisiana, and Helena, Alabama. Has 74 miles of 6-in. for *Tennessee Gas Transmission Company* between the Brazos River near West Columbia, Texas, and Lavaca Bay.

Photo courtesy Trans-Canada Pipe Lines, Ltd.

ON TRANS-CANADA PIPE LINES' 2,250-mile natural gas line, this fast working Cleveland 190 backfiller stays on the heels of the lowering-in gang. Boggy areas such as shown here near Swift Current, Saskatchewan, were frequently encountered. Perfectly balanced on wide, non-packing crawlers, the big 190 licks all types of terrain —swamps, hills, mountains—efficiently backfills heavy and light soils on both large and small diameter lines.

THE CLEVELAND TRENCHER COMPANY, 20100 St. Clair Avenue, Cleveland 17, Ohio

Pipe Line Contractors

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston 19, Texas.** Has 400 miles of 24 to ¾-in. line for Spokane *Fuel and Gas Company* for natural gas distribution system within the city of Spokane, Washington. Job closed down for the winter.

● **Latex Construction Company of Georgia, P. O. Box 184, Fond du Lac, Wisconsin.** Has 90 miles of 16 and 20-in. line between Oshkosh and Milwaukee, Wisconsin for *Michigan-Wisconsin Pipe Line Company*.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has contract for 50 mile gathering system at Redwater, Alberta. Has 40 mile gathering system to lay for *Westspur Pipeline* in the Estavan, Saskatchewan, area. Has 39 miles of 12-in. for *Imperial Oil Limited* between Waterdown and North Toronto, Ontario. Also has 106 miles of 34-in line for *Trans-Canada Pipe Lines, Ltd.*, between Burstall and Stewart Valley, Saskatchewan. Has undetermined amount of city distribution system for *Consumer Gas Company* in Toronto.

● **Collins Construction Company, Box 86, Port Lavaca, Texas.** Has contract with *U. S. Government Agencies in Europe* to lay 8000 ft of 24-in. sea-loading line in Bay of Biscay, Also has 37,000 ft of 22-in. submarine pipe line installations to lay for the *City of Los Angeles*, California. The installation, the Hyperion sludge line, extends from the beach near El Segundo to a depth of 300 ft offshore.

● **Panama-Williams Corporation, 1418 Melrose Building, Houston, Texas.** Has 76 miles of 4 and 6-in. line for *Phillips Chemical Company* between Pasadena and Sweeny, Texas.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has as joint venture with H. C. Price Company contract for 121 miles of 22-in. natural gas line for *American Louisiana Pipe Line Company* from near Defiance, Ohio, west to the vicinity of Bridgeman, Michigan. Has 120 miles of 20-in. and 11 miles of 16-in. natural gas line to lay for *Texas Gas Transmission Corporation* from the vicinity of Eunice, Louisiana, east to the vicinity of Thibodaux, Louisiana. Also has 30 miles of 8 and 12-in. natural gas lateral lines for *Tennessee Gas Transmission Company* in the vicinity of Golden Meadow and Leeville, Louisiana. Also has 121 miles of 30-in. natural gas pipe line for *Texas Eastern Transmission Corporation* from a point near Angleton, Texas, east to a point near Vidor, Texas. Work to start about March 1, 1957, based on receipt of pipe and materials.

● **Ross-Powers Construction Company, Box 2038, Billings, Montana.** Has 40 miles of 12-in. line for *Montana-Dakota Utilities Company* between Baker and Glendive, Montana. Also has 10 miles of 6-in. to lay eastward from Cabin Creek, Montana, for the same company.

● **M. G. M. Construction Company, P. O. Box 1056, Concord, California.** Has 25 miles of 6-in. for *Pacific Gas & Electric Company* from San Ardo gas fields to King City, California.

● **Western Construction Company, P. O. Box 798, Austin 64, Texas.** Has 12 miles of 30-in. for *Transcontinental Gas Pipe Line Corporation* between Scottsville and Charlottesville, Virginia. Also has contract for a 30-in. Susquehanna River crossing for the same company.

● **Engineering-Construction Company, 407 First National Building, Tulsa, Oklahoma.** Has undetermined amount of 1¼ through 8-in. city distribution lines in the town of Brookings, South Dakota, for *Northwest Public Service Company*.

● **Fulton Banister Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 18 miles of 6-in. line to lay for *Mid-Western Gas Ltd.* between Redwater and Fort Saskatchewan, Alberta.

● **Holdren Construction Company, P. O. Box 417, Mount Vernon, Illinois.** Has 12 miles of 4-in. line to lay for *Town Gas Company of Illinois* extending from the Panhandle-Eastern line below Auburn to Girard, Illinois. Also has 42 miles of small distribution lines to lay for the same company in the cities of Virden, Girard, and Thayer, Illinois.

Canadian Oil Companies Build New Toronto Building

A modern glass and aluminum building will house the new head office of Canadian Oil Companies, Ltd., on the west side of University Avenue between Richmond and Adelaide Streets, it has been announced.

Canadian Oil Company will occupy 50,000 sq ft of the 100,000 sq ft available office space. The tailor-made office accommodation will provide adequate space for the expanding activities of the company.

Plans call for the building to be completed in July, 1957, when Canadian Oil Companies, Ltd., will move in.

softening up
a rough spot
in pipelining . . .
The NEW Crose Pipeline DITCH PADDER
Forward Thinking Crose Engineering has produced another machine to reduce pipeline construction costs! This ditch padder has a screening head and conveyor that completely pads coated pipe with selected soft, rock-free soil. Sharp, pipe-damaging rocks are eliminated. No longer must padding material be hauled in from distant locations—now you can use all the good material from the spoil bank.
The Crose self-powered unit is quickly attached or detached from a standard pipeline side-boom tractor in a matter of minutes . . . releases tractor for other work along the line when not padding pipe.
This new Crose equipment will tremendously reduce your padding costs. For further information, write or call Crose today.
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Manufacturing Company, Inc.
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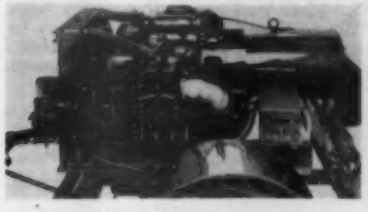
DISTRIBUTOR: *CROSE-CURRAN LTD. — EDMONTON, ALBERTA — PHONE 3-5135
*Warehouses in 4 locations

NEW Pipe Line Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(81) 12,000-W Diesel Engine-Generator Unit. Witte Engine Works announces its Model 100RDA for microwave installa-



tions. This unit is designed to produce 12,000-w continuously, 24-hr a day.

A heavy-duty, industrial-type generator is direct-connected to an 18-hp, water-cooled diesel engine. The engine is designed with horizontally opposed cylinders. This horizontal, balanced design makes possible an extremely strong unit with a low profile (approximately 30-in. high), so that it is suitable for all types of installations, particularly where space must be conserved.

Witte Engine Works, Oil Well Supply Division, United States Steel Corporation.

(82) One-Man Operation Pipe Pusher. The Pow-r Mole is a compact device for pushing in water and gas lines and pulling copper or lead lines up to 3 in. in diameter under roads, streets, sidewalks, lawns or wherever it's better not to dig up the surface.

It is said to replace the bucket on any standard tractor-mounted hydraulic backhoe using the two-bucket mounting pins. One man can operate the unit. The Pow-r Mole has a 4-in. stroke instead of the usual 2½ in. or 3 in. and operates at up to 30 tons pressure.

Pow-r Devices, Inc.

(83) Gasoline Injection. Development of a gasoline fuel injection system for internal combustion engines has been announced by Borg-Warner.

Fuel injectors, which may eventually replace the conventional carburetor on cars, trucks, and tractors, are currently commanding special attention throughout the automobile industry.

In an engine equipped with fuel injection, precisely metered amounts of fuel are sprayed directly into the air in the intake manifold at a point just before it enters the cylinder. Air for the air-fuel mixture is brought to this point separately and does not mix with the fuel until the two meet at the combustion chamber opening.

Borg-Warner Corporation.

(84) Stumper. A stumper, Ransone Model R100, has been introduced by Ransome.

This three-prong stumper can be attached to any bulldozer blade from 35 in. to 51 in. in height. Model R100 features a positive clamping device which permits its being mounted or dismounted in a matter of minutes, freeing the bulldozer for gathering stumps. No alterations to the bulldozer blade are required.

The Ransome Corporation.

(85) Compatible Coal Tar Primer. A priming solution developed especially for use with Tapecoat coal tar protective coatings has just been announced by Tapecoat.

Product, known as TC Primecoat, is designed to give users a primer that is compatible with the coal tar-pitch base used in Tapecoat protective materials.

TC Primecoat is available in 1-gal cans, packed 2 gal to the carton. Application coverage is 400 sq ft per gal.

The Tapecoat Company.

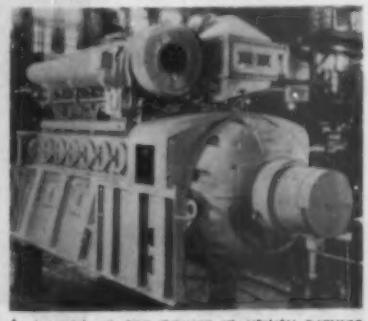
(86) Vent-Marker Test Leads. An L & M Marker Vent with a built-in junction box for cathodic-protection test leads is being marketed by the L & M Company.

The junction box is cast in one piece with a marker vent and eliminates the

need for all other signs, posts, return bends, and junction boxes at road crossings. Marker vent is cast of heavy malleable aluminum alloy with the sign panel custom-designed and painted to match company colors.

Tod Pazdral Pipe Line Specialties.

(88) New Engine Design. Recently introduced by Worthington, the W9 is a small, heavy-duty, 4-cycle, compact unit with



400-1400 hp for power in utility service, pipe lines, and chemical and petroleum plants.

Fully assembled upon delivery, the W9 "Power Package" is ready to be placed upon its foundation and requires no major aligning. Constructed for continuous operation, unit has been designed from start to finish for high-output, turbo-supercharged operation.

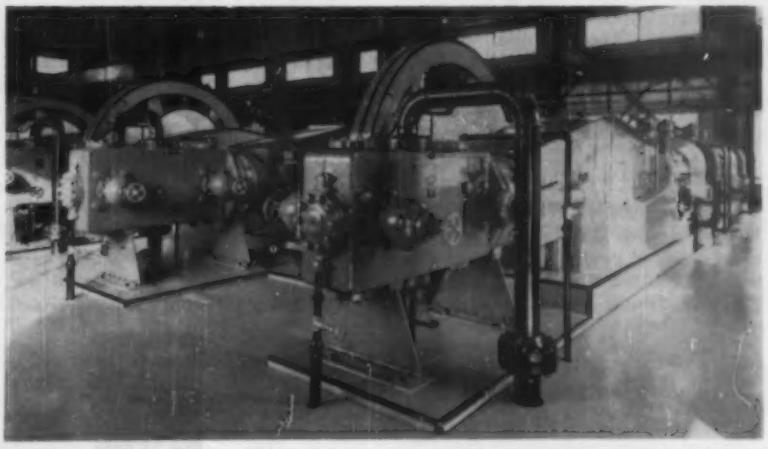
Worthington Corporation.

(89) Leakproof Plug Valve. A plug valve that is said to provide absolute leakproof shut-off is now being manufactured by Circle Seal Products.

Design of the plug features the use of three "O" rings. In the closed position, one "O" ring contained on the surface of the plug (90 deg from the flow passage through the plug) serves as a flow seal. Static "O" rings at the top and bottom of the plug and around its circumference are claimed to prevent stem leakage.

Plug valve is made of brass and is available in ¼ in. female pipe connections.

Circle Seal Products Company, Inc.



(87) Early Horizontal Gas Compressors Modernized. Through the application of compressor cylinders built of nodular iron, older type horizontal compressors can now be converted to handle 2000 psi for modern transmission and gas storage service.

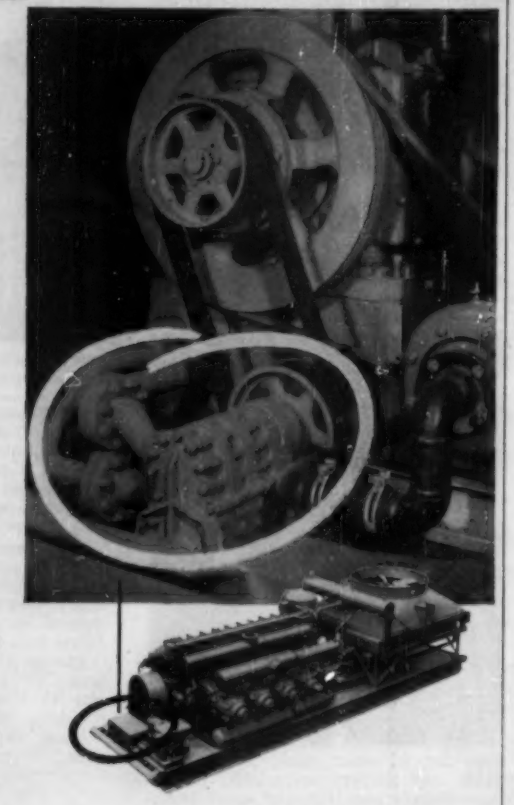
These compressor cylinders designed for 2000 psi service are supplied by Cooper-Bessemer for its own Type 22 units. They are said to be the first of their kind to be constructed of nodular or ductile iron. Previously compressor cylinders built of cast iron have been limited largely to 1000 psi service.

The Cooper-Bessemer Corporation.

496
COST CUTTING CASE STUDY

BERRY® Hydraulic Drives . . .
Standard on Clark Compressors

TAKE A TIP FROM CLARK



Berry drives give:

- COOL WEATHER ECONOMY
- PRECISION TEMPERATURE CONTROL
- INFINITELY VARIABLE FAN SPEED
- FLEXIBLE FAN LOCATION
- LOWER MAINTENANCE COST
- SIMPLIFIED POWER TRANSMISSION

These are the reasons Clark Bros., Inc. standardized on Berry Hydraulic Drives to run the direct mounted radiator fans on their portable, skidmounted HMA-B Compressors. They replace conventional belt drive and jack shaft. Clark finds that versatile Berry Drives give them greater latitude in locating the radiator fan. Their customers like the infinitely variable fan speed that can be changed to fit the cooling requirement. Since input horsepower is only that necessary to operate the fan under any given temperature condition, there is a saving in power during cooler weather. Proved too, are lower upkeep costs and longer component life resulting from the cushioning effect of fluid power.

What does this mean to You?

The advantages of Berry Hydraulic Drives can be translated into lower costs on *your* power transfer requirements. Economical and easy to install, Berry Hydraulic Pump/Motor Drives assure smooth, sure, foolproof power at infinitely variable speeds. They are quiet running with maximum power efficiency. And, you can depend on Berry Hydraulic Pump/Motor Drives!

Send for this catalog now!
It's packed with simplified cutaways and data that tell you the "why" and "how" of Berry Hydraulic Drives.

BERRY DIVISION
OLIVER IRON AND STEEL CORPORATION
PITTSBURGH 19, PA.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers.

(90) Full-Flow Valves. A 4-page bulletin dealing with eight types of Coppus Sentry Full-Flow Valves is now available from Coppus Engineering. Bulletin covers in considerable detail the design, function, and specifications of these advanced valves.

Coppus Engineering Corporation.

(91) Pneumatic Controllers. A 56-page bulletin describing the Series 500W Pneumatic Controller has been announced by Bristol.

This two-color bulletin is illustrated by more than 75 photos and drawings, describing the new high-sensitivity, wide control-band controllers for temperature, pressure, flow, vacuum, etc. Features of the new controllers mentioned include: control band width ½ per cent to 400 per cent, high sensitivity without loss of stability, precision linkage allowing reassembly and recalibration with only one adjustment, and reset action stops.

The Bristol Company.

(92) Hydraulic Fan Drives. De Laval Steam Turbine has released a bulletin that describes its hydraulic fan drive for air-cooled heat exchangers and cooling towers.

The 6-page, illustrated bulletin includes detailed information on the IMO motors and pumps and the worm gear reducers that make up the fan-drive unit. Also included in the bulletin are performance curves useful for selecting the right unit for specific applications.

De Laval Steam Turbine Company.

(93) Lubricating Threaded Connections. Lubrication of threaded connections is featured in the second issue of the Lubrication Newsletter now available from Alpha Molykote.

Lead article is a technical description of the causes of galling and seizing in threaded connections and power screws and procedures for lubrication to practically eliminate these problems. Descriptive charts show coefficients of friction as calculated from both torque wrench measurements and test data using a threaded assembly.

The Alpha Molykote Corporation.

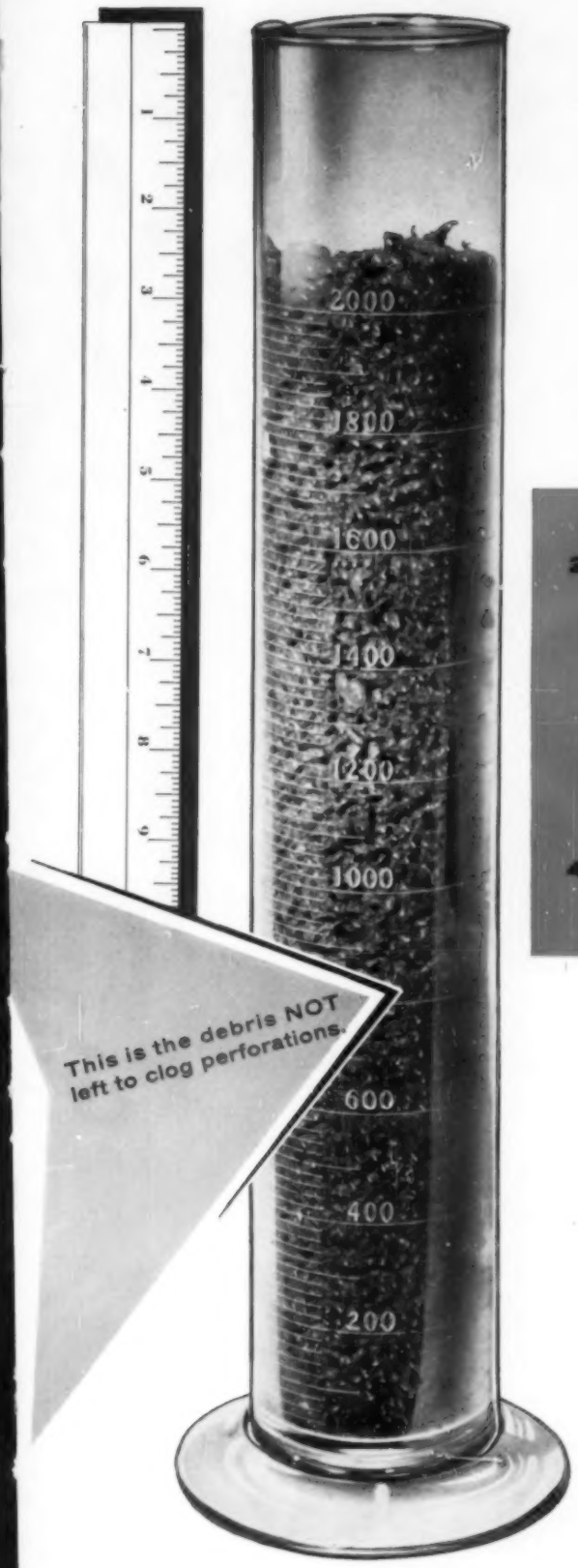
(94) Diesel Engines. An illustrated brochure describing General Motors Turbopower Diesels has been issued by the Detroit Diesel Engine Division. Specifications of industrial and marine models ranging from 159 to 300 bhp are fully described along with features of design and performance data.

Detroit Diesel Engine Division, General Motors Corporation.

(95) Butterfly Valve. Henry Pratt has issued a 40-page catalog designed to help engineers select valve types, understand their characteristics, and determine space requirements.

Catalog includes such data as: Pressure drop and flow tables, conversion tables, theory and application, recommended materials and describes Henry Pratt Rubber Seat Butterfly Valves from 4-in. diam up, for handling liquids and gases.

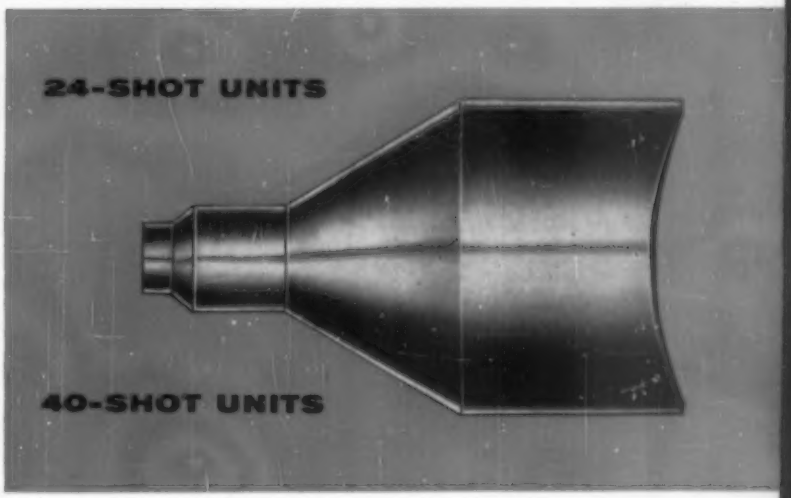
The Henry Pratt Company.



Lane-Wells

POWER-PAK CHARGES

mean cleaner, karrotfree koneshot PERFORATIONS



Lane-Wells designed and perfected Karrotfree Koneshot Perforating to give the industry cleaner perforations without loss of penetration. Power-Pak Koneshot charge design gives you all the advantages of Karrotfree perforating plus, on actual test, deeper clean, debris-free perforations.

Power-Pak perforating, an original exclusive Lane-Wells development, is available only through Lane-Wells Branches. For consistently better perforating results, call Lane-Wells and "get the job done right."

LANE WELLS COMPANY

Write for complete information to
P. O. Box 1664, Houston 1, Texas

LANE-WELLS CANADIAN CO. IN CANADA
PETRO-TECH SERVICE CO. IN VENEZUELA

Tomorrow's Tools - Today!

GREET
HALLIBURTO
OIL WELL CE

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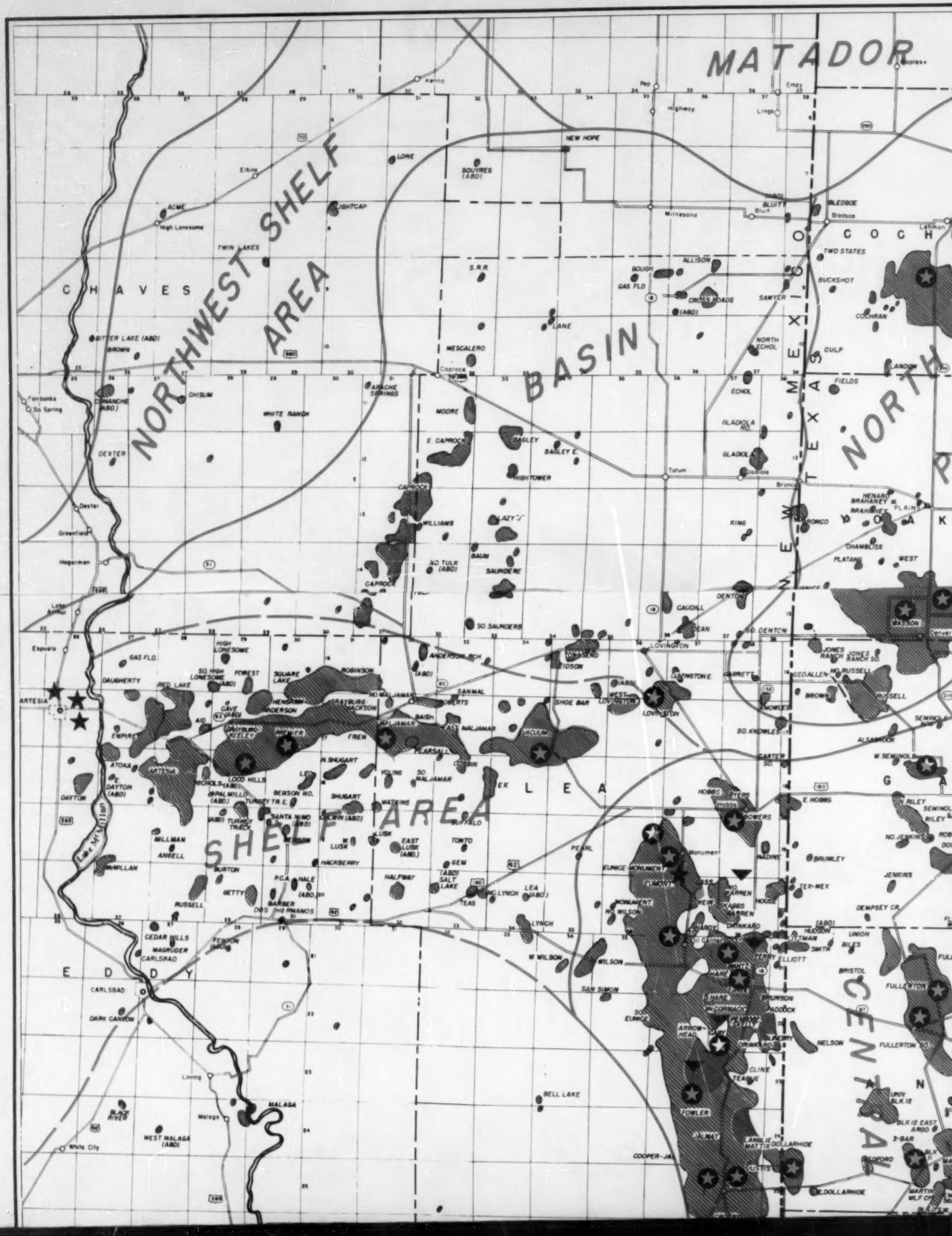
CEMENTING COMPANY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MALAGA
HOBBS
LOVINGTON
TATUM
CAPROCK
MAJAMAR
EAST MAJAMAR
SO. MAJAMAR
SHOE BAR
VACUUM
EMPIRE
MORROW
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E. DAYTON (ABD)
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SQUARE LAKE
ROBINSON
HIGH LONESOME
SO. HIGH LONESOME (ABD)
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RED LAKE
CAVE (ABD)
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WILLIAMS
ANDERSON RCH (ABD)
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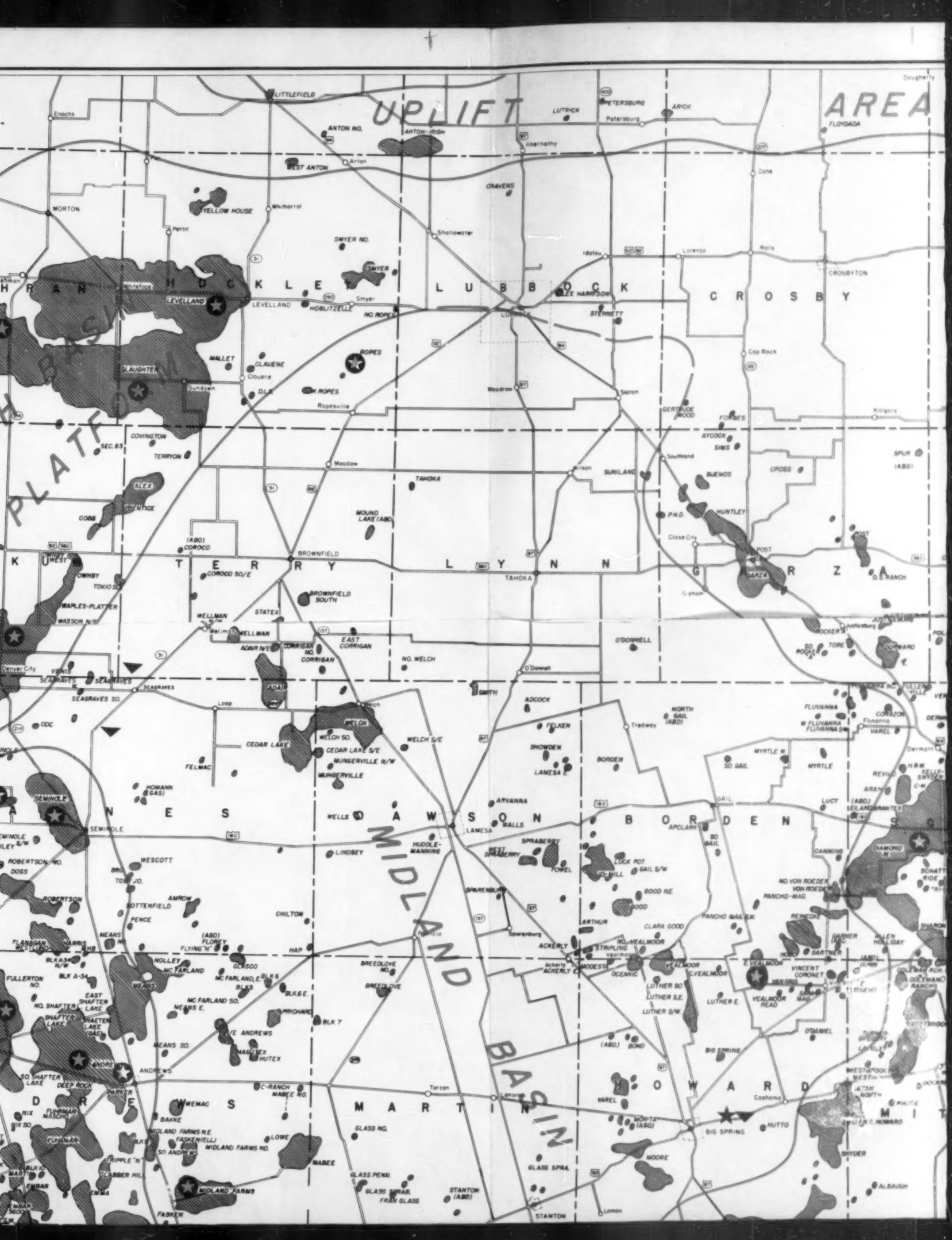
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LEVELLAND
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TAHOKA
Plains
SUNDOWN
BUENOS
GROSS
SPUR (ABO)
ALEX
PRENTICE
COBB
MOUND LAKE (ABO)
P.N.D.
HUNTLEY
Close City
POST
(ABO) COROCO
BROWNFIELD
TAHOKA
O'DONNELL
OWNBY
TOKIO SO.
COROCO SO/E
BROWNFIELD SOUTH
WARLES-PLATTER
WASSON N/E
STATEX
WELLMAN
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O'Donnell
Denver City
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PANCHO MAG BLK
REINECKE
ARTHUR
CLARA GOOD
ACKERLY
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STRIPLING
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VAN GRAD
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LUTHER E.
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HALEY HOLLIDAY
SHARON RIDGE
GOLDSMITH RCH.
GOLDSMITH RANCH
O'DANIEL
(ABO) BOND
BIG SPRING
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HARRIS
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C-RANCH
MABEE NO.
Tarzan
Lenorah
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Kalgary
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Gross
Huntley
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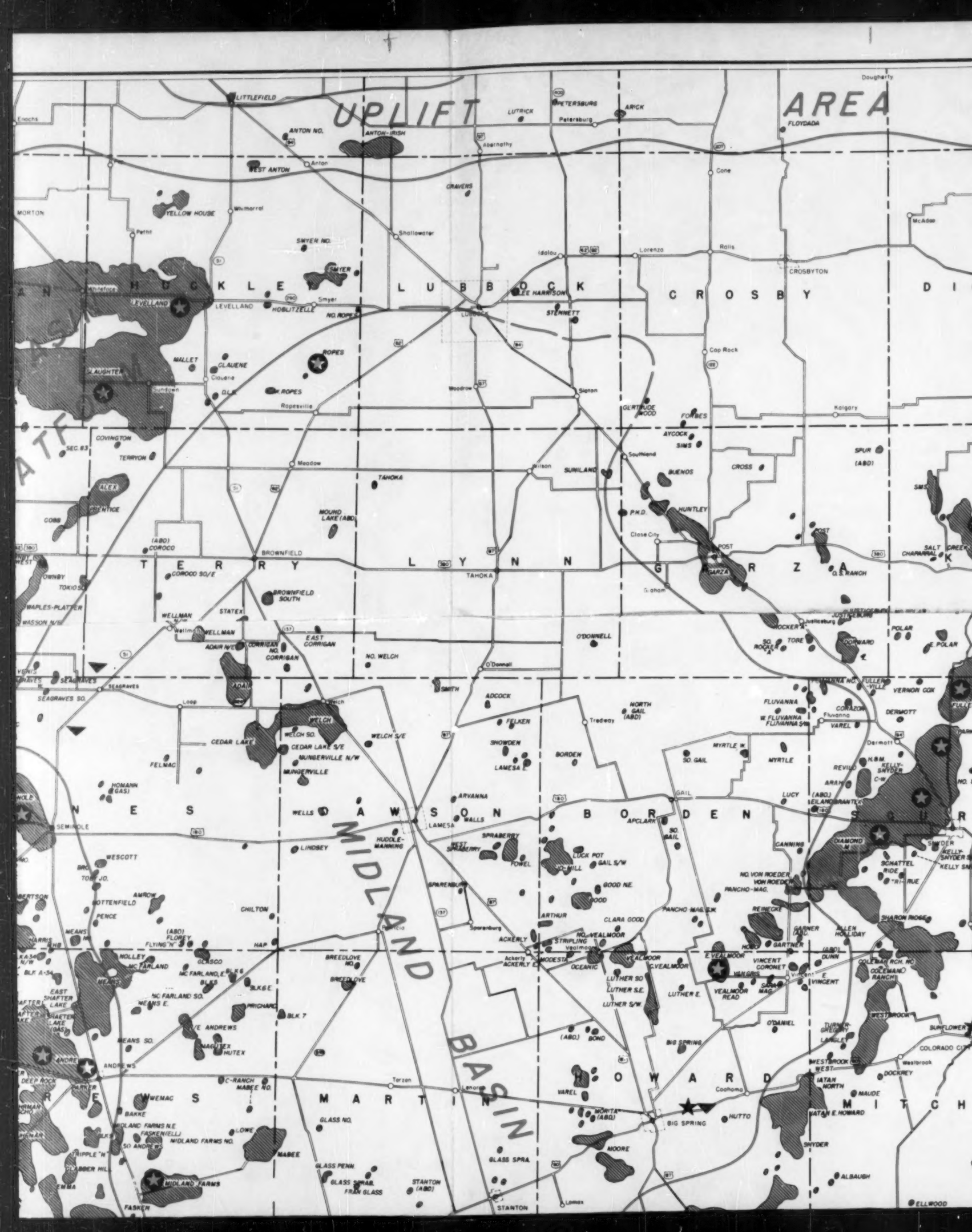
Garza
Tahoka
Brownfield
Loop
Seagraves
Welch
Smith
Adcock
Tredway
Fluvanna
Snyder
Borden
Gail
Lamesa
Wells
Walls
Apclark
Ackerly
Big Spring
Howard
Mitchell
Andrews
Seminole
Denver City
Plains
Morton
Littlefield
Anton
Levelland
Lubbock
Crosby
Slaton
Ropesville
Meadow
Brownfield
O'Donnell
Tahoka
Lynn
Terry
Yoakum
Gaines
Dawson
Martin
Howard
Mitchell
Scurry
Kent
Garza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AREA
MIDLAND BASIN
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ANTON NO.
ANTON-IRISH
WEST ANTON
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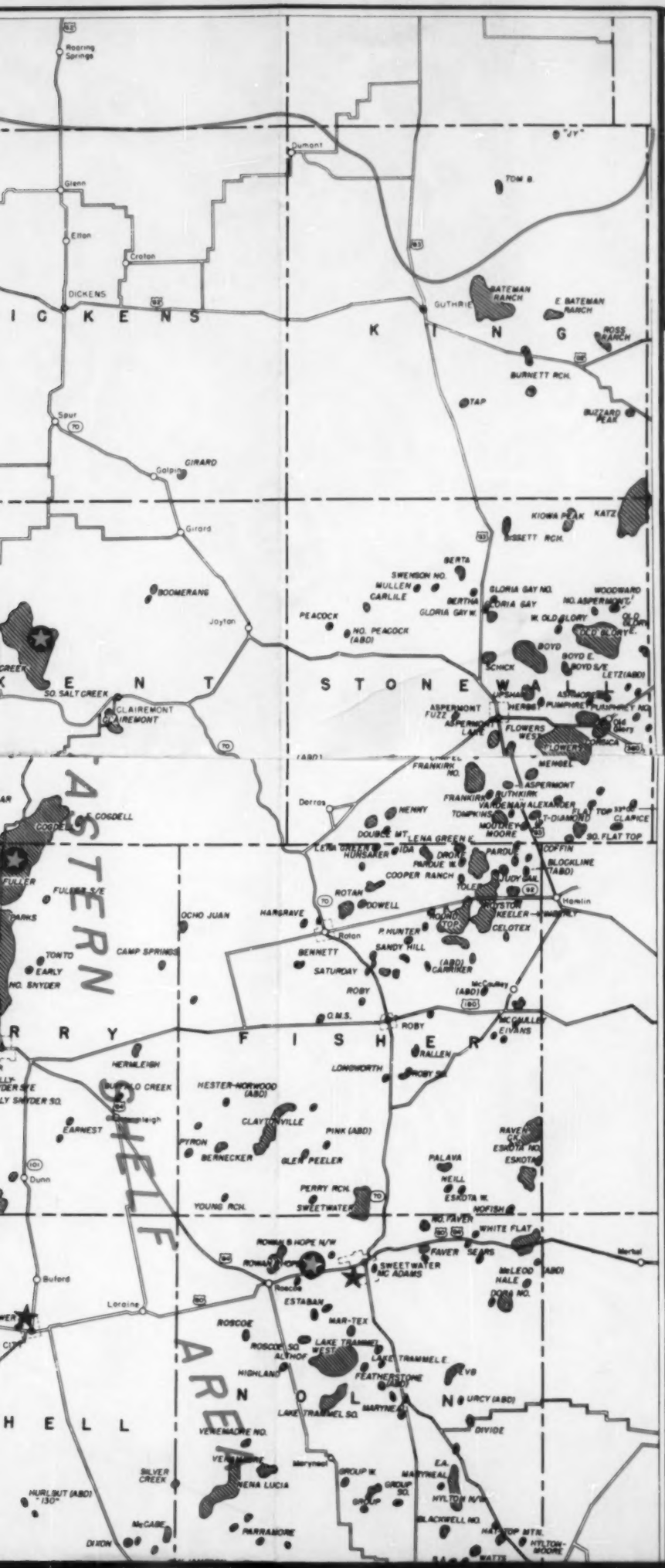
Abernathy
Petersburg
LUTRICK
ARICK
FLOYDADA
Dougherty
Cone
CROSBYTON
Crosby
Lorenzo
Ralls
McAdoo
Idalou
LUBBOCK
LEE HARRISON
STENNETT
Lubbock
Shallowater
Whitharral
YELLOW HOUSE
Petit
MORTON
SMYER NO.
SMYER
Smyer
LEVELLAND
HOBBITZELLE
NO. ROPES
ROPES
Ropesville
MALLET
CLAUENE
Clauene
SLAUGHTER
Sundown
Meadow
Sterton
Woodrow
GERTRUDE WOOD
FORBES
Kalgary
Cap Rock
AYCOCK
SIMS
SPUR (ABD)
COVINGTON
TERRYTON
SEC. 63
Wilson
SUNLAND
Southland
BUENOS
CROSS
TAHOKA
MOUND LAKE (ABD)
P.M.D.
HUNTLEY
Close City
POST
SALT CHAPARRAL CREEK
COROCO
(ABD)
BROWNFIELD
Terry
Lynn
Garza
TAHOKA
G.E. RANCH
Graham
COROCO SO/E
BROWNFIELD SOUTH
STATEX
WELLMAN
WELLMAN N/W
ADAIR N/E
CORRIGAN
NO. CORRIGAN
EAST CORRIGAN
NO. WELCH
O'DONNELL
ROCKER A
SO. ROCKER A
TORE
NORWARD
POLAR
E. POLAR
SEAGRAVES
SEAGRAVES SO.
Loop
Welch
WELCH
WELCH SO.
WELCH S/E
CEDAR LAKE
CEDAR LAKE S/E
MUNGERVILLE N/W
MUNGERVILLE
FELNAC
HOMANN (GAS)
SMITH
ADCOCK
FELKEN
SNYDER
LAMESA E.
BORDEN
Tredway
NORTH GAIL (ABD)
FLUVANNA
W. FLUVANNA FLUVANNA S/W
CONZON
Fluvanna
VAREL
DERMOTT
VERNON COX
Dermott
MYRTLE W.
MYRTLE
SO. GAIL
REVILO
K&M
KELLY-SNYDER
C-W
ARAPAHO
(ABD) SEILAND-TEXAS
GAIL
LUCY
Nesbitt
Sawyer
Borden
SEMINOLE
ARVANNA
WELLS
WALLS
LAMESA
APCLARK
SO. GAIL
SPRABERRY
WEST SPRABERRY
HUDDLE-MANNING
LINDSEY
LUCK POT
NO. MILL
GAIL S/W
FOWEL
GOOD
GOOD NE.
CANNING
DIAMOND M
SCHATTEL RIDGE
SNYDER
KELLY-SNYDER
KELLY SW
NO. VON ROEDER
VON ROEDER
PANCHO-MAG.
PANCHO MAG E.W.
REINECKE
SHARON RIDGE
WESCOTT
TOM JO.
AMROW
BOTTENFIELD
PENCE
CHILTON
ARTHUR
CLARA GOOD
SPARENBURG
Sparenberg
ACKERLY
STRIPLING
NO. VEALMOOR
Vealmoor
MODESTA
OCEANIC
VEALMOOR
E. VEALMOOR
G. VEALMOOR
LUTHER SO
LUTHER S.E.
LUTHER S/W
LUTHER E.
VEALMOOR READ
GARDNER (ABD)
HOBBS
GARTNER
ALLEN HOLLIDAY
(ABD) DUNN
VINCENT CORONET
VINCENT
E. VINCENT
COLEMAN RCH. NO.
COLEMAN RANCH
HARRIS
MEANS NE
MEANS
(ABD) FLOREY
FLYING "N"
HAP
HOLLEY
MC FARLAND
GLASCO
MC FARLAND E.
BLK 6
BLK 6 E
MC FARLAND SO.
MEANS E.
PRICHARD
BLK 7
EAST SHAFTER LAKE
SHAFTER LAKE (GAS)
SHAFTER LAKE
BREEDLOVE NO.
BREEDLOVE
E/E ANDREWS
MAGUTEX
HUTEX
MEANS SO.
ANDREWS
Andrews
Terzen
Lenorah
C-RANCH
MABEE NO.
Howard
Martin
Mitchell
SWEMAC
BAKKE
MIDLAND FARMS N.E.
FASKEN (ELL)
MIDLAND FARMS NO.
SO. ANDREWS
LOWE
MABEE
GLASS NO.
GLASS PENN
GLASS SPRAB.
FRAN GLASS
STANTON (ABD)
GLASS SPRA.
MIDLAND FARMS
FASKEN
TRIPPLE "N"
RABBIT HILL
EMMA
Coahoma
VAREL
MORITA (ABD)
BIG SPRING
HUTTO
MOORE
STANTON
Lamesa
O'DANIEL
(ABD) BOND
BIG SPRING
WESTBROOK
WESTBROOK WEST
IATAN NORTH
IATAN E. HOWARD
MAUDE
DOCKERY
SUNFLOWER
COLORADO CITY
Westbrook
SNYDER
ALBAUGH
ELLWOOD



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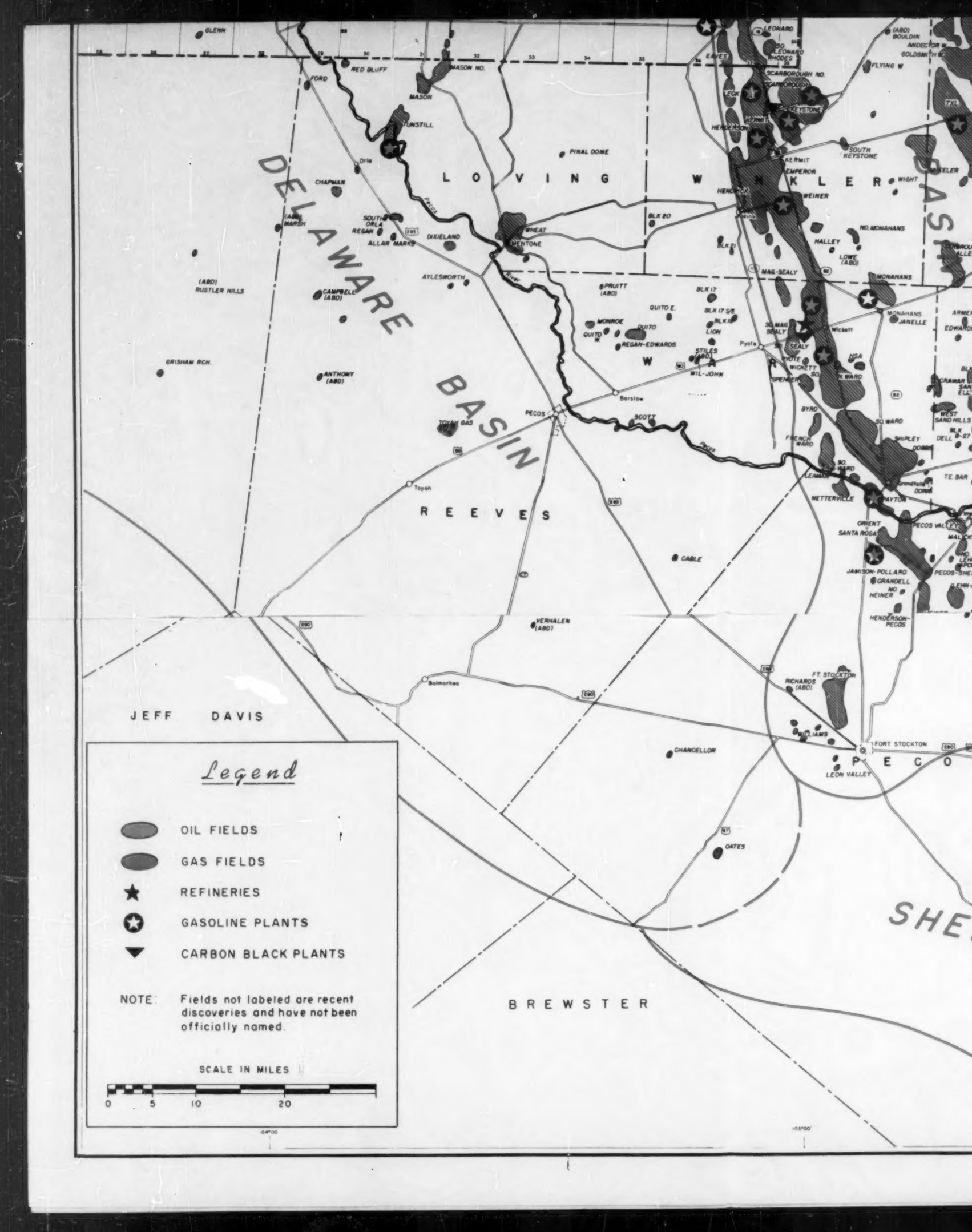
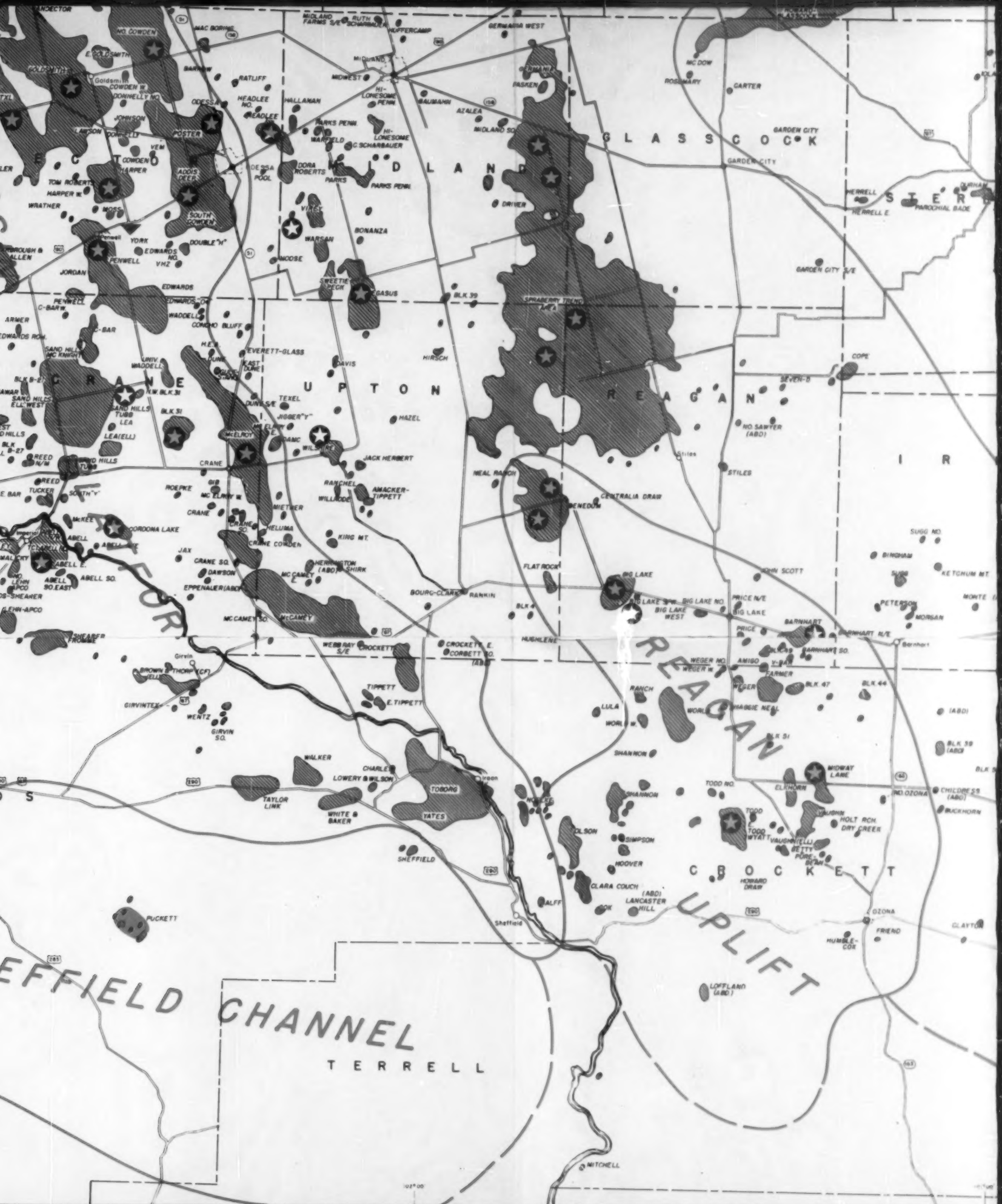
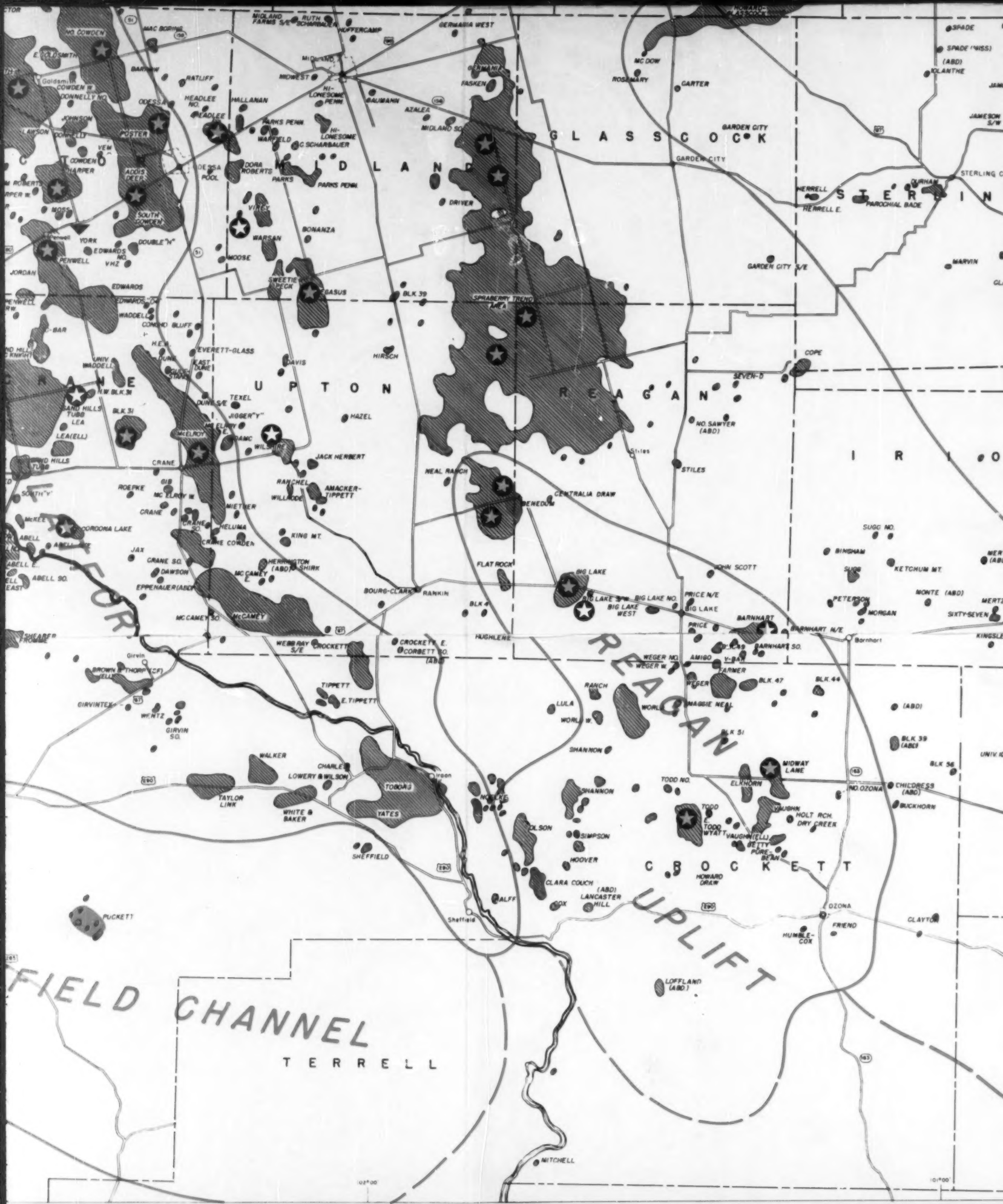
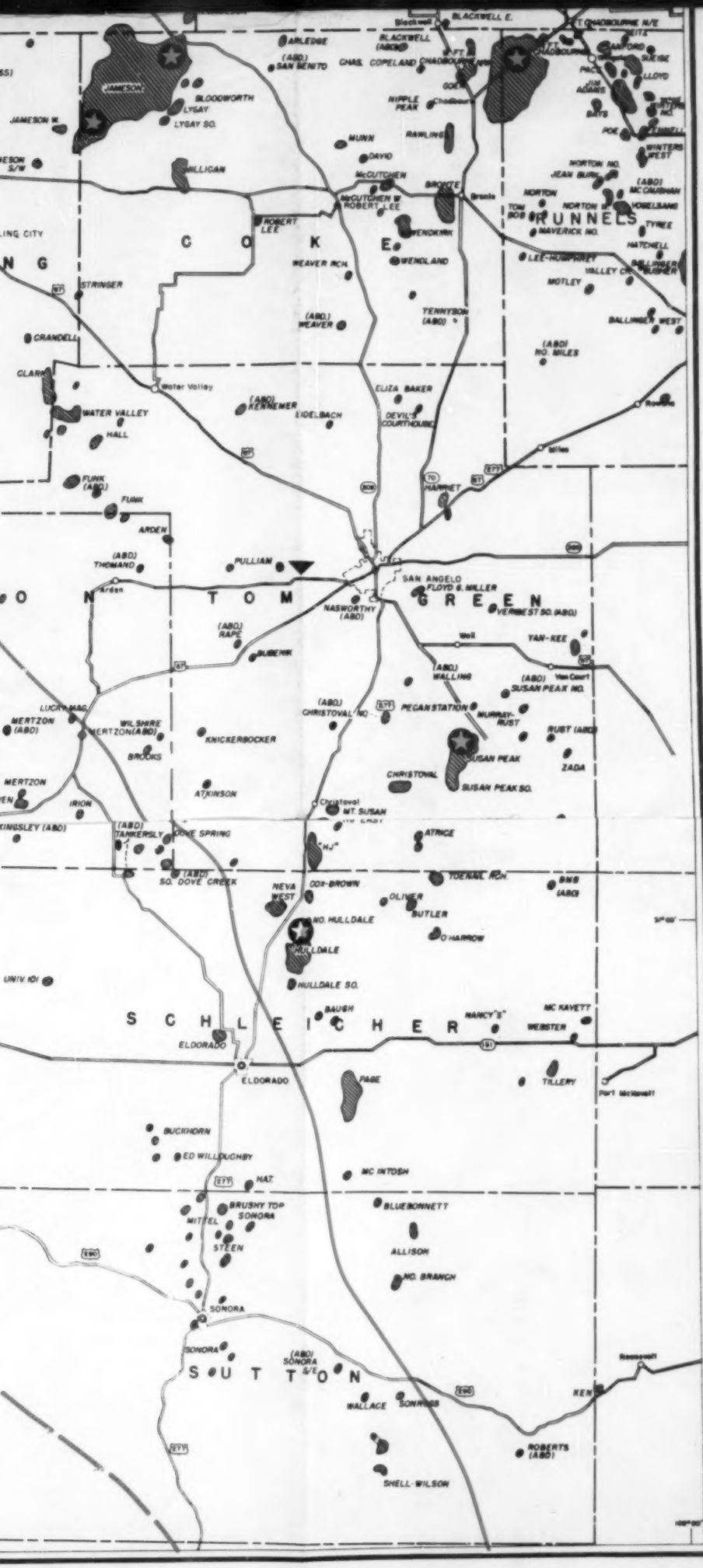
Oil and Gas Fields of the Permian Basin in WEST


DELAWARE BASIN
LOVING
WINKLER
REEVES
JEFF DAVIS
BREWSTER
PECOS
Legend
OIL FIELDS
GAS FIELDS
REFINERIES
GASOLINE PLANTS
CARBON BLACK PLANTS
NOTE: Fields not labeled are recent discoveries and have not been officially named.
SCALE IN MILES
0 5 10 20


MIDLAND
GLASSCOCK
ECTOR
CRANE
UPTON
REAGAN
IRION
CROCKETT
TERRELL
MIDLAND FARMS S/E
RUTH (CONSOLIDATED)
HUFFCAMP
GERMANIA WEST
MC DOW
ROSEMARY
CARTER
MIDWEST
HI-LONESOME PENN
BAUMANN
PASKEN
AZALEA
MIDLAND SO.
GARDEN CITY
GARDEN CITY S/E
HERRELL
HERRELL E.
PAROCHIAL BADE
MAC BORING
NO. COWDEN
E. COWDEN SMITH
GOLDSMITH
COWDEN W.
DONNELLY NO.
RATLIFF
ODESSA
HEADLEE NO.
HEADLEE
HALLANAN
JOHNSON
LAWSON
POWELL
FOSTER
VEM
COWDEN
HARPER
ADDIS DEEP
TOM ROBERTS
HARPER W.
WRATHER
MOSS
SOUTH COWDEN
ODESSA POOL
DORA ROBERTS
PARKS PENN
WARFIELD
HI-LONESOME
C. SCHARBAUER
PARKS
DRIVER
WARSAN
BONANZA
MOOSE
SWEETIE PECK
PEGASUS
BLK. 39
SPRABERRY TREND AREA
YORK
EDWARDS NO.
EDWARDS VNZ
DOUBLE "A"
PENWELL
JORDAN
EDWARDS
EDWARDS-CO
WADDELL
COMCHO BLUFF
PENWELL C-BAR
C-BAR
ARMER
EDWARDS ROW
SAND HILLS MC KNIGHT
UNIV. WADDELL
EVERETT-GLASS
EAST DUNE
DAVIS
HIRSCH
COPE
SEVEN-D
NO. SAWYER (ABO)
STILES
BLK 9-27
SAND HILLS ELL WEST
REED N/M
SAND HILLS
TUBB
LEA
LEA (ELL)
BLK 31
NW. BLK 31
DUNE S/E
TEXEL
HOGER "Y"
MAZEL
McELROY
DANC
WILSON RE
JACK HERBERT
CRANE
REED
TUCKER
SOUTH "Y"
ROEPKE
MC ELROY W.
RANCHEL WILLARD
AMACKER-TIPPETT
MEAL RANCH
CENTRALIA DRAW
BENEDUM
CRANE
McKEE
CORDONA LAKE
ABELL
ABELL E.
ABELL SO. EAST
ABELL SO.
JAX
CRANE SQ.
DAWSON
EPPENAUER (ABO)
HELUMA
CRANE COWDEN
KING MT.
HERRINGTON (ABO)
SHIRK
MC CAMEY E.
BOURG-CLARK
RANKIN
FLAT ROCK
BIG LAKE
BIG LAKE S/W.
BIG LAKE NO.
BIG LAKE WEST
PRICE N/E
BIG LAKE
JOHN SCOTT
SUGG NO.
BINGHAM
SUGG
KETCHUM MT.
MONTE
PETERSON
MORGAN
BLK 4
MC CAMEY SO.
McCAMEY
HUGHLENE
BARNHART
BARNHART N/E
Barnhart
BARNHART SO.
WEBB RAY S/E
CROCKETT
CROCKETT E.
CORBETT NO. (ABO)
WEGER NO.
WEGER W.
AMIGO
WEGER
FARMER
BLK 47
BLK 44
RANCH
LULA
WORLEY
WORLEY W.
MAGGIE NEAL
(ABO)
BLK 51
BLK 39 (ABO)
SHANNON
MIDWAY LANE
ELKHORN
TODD NO.
NO. OZONA
CHILDRESS (ABO)
BUCKHORN
TODD
TODD WYATT
VAUGHN
HOLT RCH. DRY CREEK
VAUGHN-ELLI
BETTY PORE-SEAH
COLSON
SIMPSON
HOOVER
CLARA COUCH
(ABO) LANCASTER HILL
HOWARD DRAW
OZONA
FRIEND
HUMBLE-COR
GLAYTON
LOFTLAND (ABO)
MITCHELL
GIRVIN
THORP (CF)
BROWN (ELL)
GIRVINTEX
TIPPETT
E. TIPPETT
WENTZ
GIRVIN SQ.
WALKER
CHARLES
LOWERY & WILSON
TOBORG
YATES
TAYLOR LINK
WHITE & BAKER
SHEFFIELD
Iraan
Sheffield
PUCKETT
FOR
REAGAN
UPLIFT
EFFIELD CHANNEL
102°00'


MIDLAND
GLASSCOCK
UPTON
REAGAN
CRANE
IRION
FORT
REAGAN
UPLIFT
COCKETT
TERRELL
FIELD CHANNEL
MIDLAND FARMS S/E
RUTH (SCHARBAUER)
HUFFCAMP
GERMANIA WEST
MAC BORING
MIDLAND NO.
MIDWEST
HI-LONESOME PENN
BAUMANN
AZALEA
MIDLAND SO.
FASKEN
MC DOW
ROSEMARY
CARTER
SPADE
SPADE (MISS)
(ABD) SOLANTHE
GARDEN CITY
GARDEN CITY S/E
HERRELL
HERRELL E.
PAROCHIAL BADE
STERLING C
MARVIN
GOLDSMITH
GOLDSMITH W
DONNELLY NO.
COWDEN W
DONNELLY
RATLIFF
ODESSA
HEADLEE NO.
HEADLEE
HALLANAN
JOHNSON
LAWSON
COWDEN
HARPER
ADDIS DEEP
SOUTH COWDEN
MOSS
ODESSA POOL
DORA ROBERTS
PARKS PENN
WARFIELD
G. SCHARBAUER
HI-LONESOME
PARKS
VIVIAN
WARSAN
BONANZA
DRIVER
YORK
EDWARDS
DOUBLE "M"
PENWELL
MOOSE
JORDAN
SWEETIE PECK
BASUS
BLK. 39
SPRABERRY TREND AREA
WADDELL
COMANCHE BLUFF
EVERETT-GLASS
DAVIS
HIRSCH
SEVEN-D
COPE
NO. SAWYER (ABD)
STILES
TEXEL
JIGGER "Y"
HAZEL
McELROY
WILSHIRE
JACK HERBERT
NEAL RANCH
CENTRALIA DRAW
BENEDUM
RAMCHEL
WILLADEE
AMACKER-TIPPETT
CRANE
ROBERTS
MC ELROY W.
MIETHER
CORDONA LAKE
HELUMA
CRANE COWDEN
KING MT.
JAX
CRANE SO.
DAWSON
EPPENAUER (ABD)
HERRINGTON (ABD)
SHIRK
McCAMEY E.
McCAMEY
McCAMEY SO.
ABELL
ABELL SO.
SUGG NO.
BINGHAM
SUGG
KETCHUM MT.
JOHN SCOTT
FLAT ROCK
BIG LAKE
BIG LAKE S/E
BIG LAKE WEST
BIG LAKE NO.
PRICE N/E
BIG LAKE
PETERSON
MONTE (ABD)
MORGAN
SIXTY-SEVEN
BOURG-CLARK
RANKIN
BLK. 4
HUGHLENE
BARNHART
PRICE
BARNHART N/E
Barnhart
BARNHART SO.
KINGSLE
CROCKETT
CROCKETT E.
CORBETT SO. (ABD)
WEGER NO.
WEGER W.
WEGER
AMIGO
FARMER
BLK. 47
BLK. 44
RANCH
LULA
WORLEY
WORLEY W.
MAGGIE NEAL
(ABD)
BLK. 51
BLK. 39 (ABD)
BLK. 56
UNIV.
SHANNON
MIDWAY LANE
ELKHORN
TODD NO.
NO. OZONA
CHILDRESS (ABD)
BUCKHORN
TODD
TODD E.
TODD WYATT
VAUGHN
VAUGHN (ELL)
BETTY PURE-BEAM
HOLT RCH.
DRY CREEK
HOWARD DRAW
OLSON
SIMPSON
HOOVER
CLARA COUCH (ABD)
LANCASTER HILL
COX
RALFF
OZONA
FRIEND
CLAYTON
HUMBLE-COX
LOFFLAND (ABD)
MITCHELL
Sheffield
TOBOSA
YATES
SHEFFIELD
WALKER
CHARLES
LOWERY & WILSON
TAYLOR LINK
WHITE & BAKER
PUCKETT
TIPPETT
E. TIPPETT
GIRVIN
GIRVIN SO.
WENTZ
GIRVINTEX
BROWN (THORP) (CF)
Girvin
SHEARER FRONIE
WEBB RAY S/E
102°00
101°00



TEXAS and SOUTHEAST NEW MEXICO

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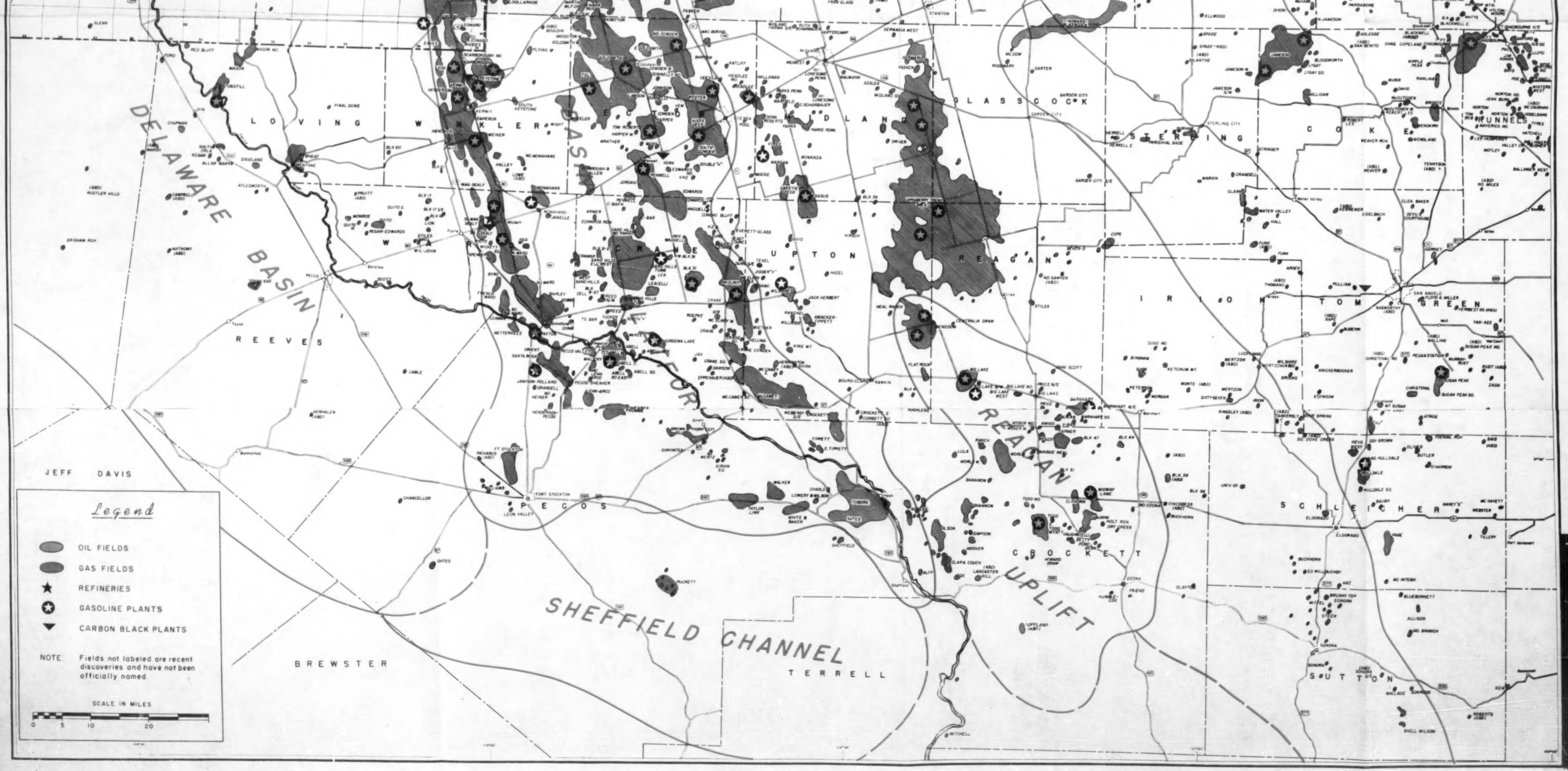

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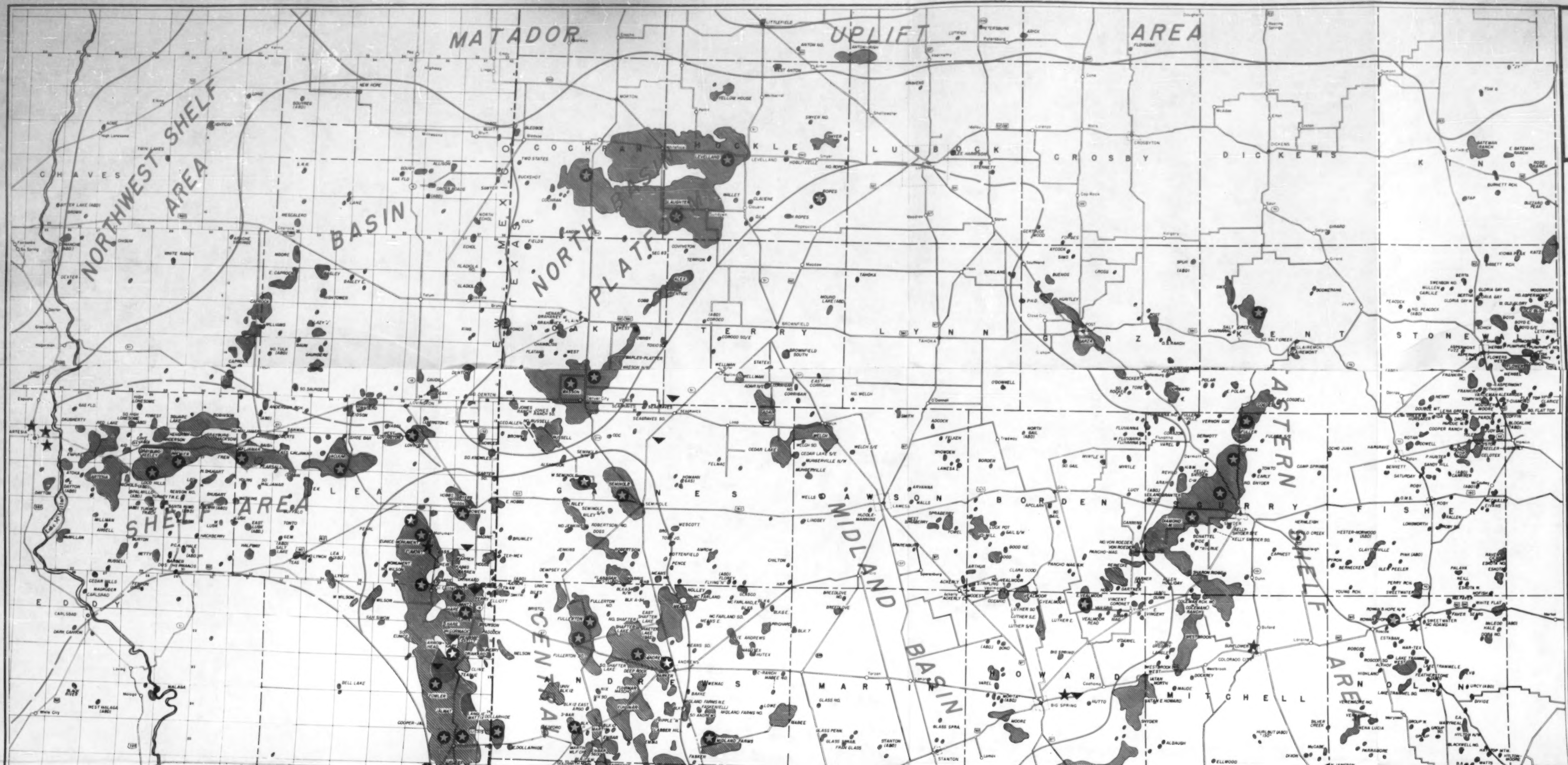

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